Final Report:

Lower Brule Sioux Tribe Wind-Pumped Storage Feasibility Study Project

Grant #DE-FG36-03GO13024

April 2007

Prepared by:

Lower Brule Sioux Tribe
187 Oyate Circle
Lower Brule, SD 57548

Table of Contents

Executive Summary

Project Overview

The Lower Brule Sioux Tribe is a federally recognized Indian tribe organized pursuant to the 1934 Wheeler-Howard Act ("Indian Reorganization Act"). It is governed by a tribal council elected at-large and comprised of five council members and a Tribal Chairman. The Chairman also acts as the Chief Executive Officer of the tribe.

The Lower Brule Sioux Indian Reservation lies along the west bank of Lake Francis Case and Lake Sharpe, which were created by the Fort Randall and Big Bend dams of the Missouri River pursuant to the Pick Sloan Act. The grid accessible at the Big Bend Dam facility operated by the U.S. Army Corps of Engineers is less than one mile of the wind farm contemplated by the Tribe in this response. The low-head hydroelectric turbines further being studied would be placed below the dam and would be turned by the water released from the dam itself. The riverbed at this place is within the exterior boundaries of the reservation. The low-head turbines in the tailrace would be evaluated to determine if enough renewable energy could be developed to pump water to a reservoir 500 feet above the river.

Throughout the years, data collected at two sites on the LBST Reservation have been collected intermittently. One site that has long been discussed as a potential site to support a commercial wind project is called the "Big Bend Site" located near the Big Bend dam. Again, past efforts to collect this data have not yielded sufficient information upon which to base a reliable feasibility study but efforts by the Tribe was restarted under new organizational leadership in order to get collection and analysis work on track. The results from these efforts, in terms of data collection and analysis on a going forward basis, provide a preliminary basis in which to base a reasoned opinion on the feasibility of commercial wind development.

Section 1: Project Objectives

Project Objectives

The initial concept to be tested for feasibility is the combination of technologies to capture the power-generation capacity of under-utilized wind and water flow for export of electricity to a WAPA grid in close proximity to a proposed wind farm site. This study was undertaken with the objective to examine the technical feasibility of the proposed combination of separate technologies.

The second question of feasibility will relate to the general economic value of the proposed installation and also determine the market potential, obstacles and costs in accessing the existing and future markets, issues related of permitting.

The location of the proposed installation will be based on the proximity to the existing grid access at Big Bend Dam (see appendices). The land in question is trust land owned by the tribe.

Section 2: Description of Activities Performed

Project Description of Activities

Activities and tasks set forth by the Tribe and the grant included:

1) Wind/Pumped Storage Project Concept Investigation

The proposed wind and pumped storage Project would provide analysis and advice as to the preliminary feasibility of utilizing a pump back water storage reservoir and attendant hydroelectric turbines to supply power during any part of a contracted period of associated wind generation that slows or stops.

The system initially sought to be reviewed would involve a potential lower head or stream flow hydroelectric turbines placed in the tailrace of the dam which would power pumping of water to a storage reservoir. The Tribe was to study whether low head turbines in the tailrace could produce enough energy to a reservoir to be constructed above the river and whether such reservoir would have sufficient head to create on demand hydropower to firm up attendant wind generation.

If deemed technically feasible, the Project was to then investigate the real value of this potential levelized or firmed-up power and potential power marketing agreements which would capture any value created.

2) Preliminary Feasibility Determinations

Overall, the Project will examine and report on each of the following feasibility determinations and a go/no-go analysis and reporting will be made. If any initial determinations are made that a proposed task is not physically, technically, legally or economically feasible then the Project will cease work on this task. The results of all tasks will be made included in the final report and will become an element of the Tribe's strategic energy planning for future development.

3) Attendant Water Development/Facility Issues

The Project will determine and report on water diversion rights and capabilities to utilize and/or consume water which could be stored and utilized in the pump back reservoir. The Project will make an initial determination and report on the technical and physical feasibility of constructing a new reservoir of sufficient size, depth and elevation above the discharge turbines and placement of low head turbines in the tail race.

4) Wind Resource and Technology Evaluation

The Project will investigate and document access to the transmission grid with power from a commercial wind farm, including the capacity of the transmission lines and potential marketing and transmission partnerships or relationships. The Project will utilize any useful past wind data collected and current data generated to assess the viability of developing a commercial wind farm, including any wind mapping that can be accomplished given the confines of budgetary concerns, including but not limited to, topographical review and other standard and reasonable wind development technical analysis that can get the Tribe further ahead in its endeavors to commercially develop wind on the Lower Brule Sioux Reservation. Initial identification of potential wind technology will be made. The micrositing process will be assessed if warranted and that analysis and recommendations will be included in the final report.

5) Economic Feasibility

The Project will provide initial analysis on projected costs of a proposed installation, which may include engineering expenses, transmission studies, equipment purchase, construction, operations and maintenance, warranties, training and leasing.

6) Political Feasibility

The Tribe will explore the political feasibility of the concept, both as relates to tribal politics, state and local politics and federal/national politics. The Tribe will measure and report on tribal members' perceptions of cultural compatibility, impact of a proposed installation on the environment, the scenic viewscape and mitigation of potential adverse impacts.

6) Assessing Environmental Benefits and Impacts, and the Permitting process

The Project will conduct a preliminary assessment of environmental, archeological and permitting requirements and issues of the site where the wind farm, and potential reservoir if appropriate, may be located. The Tribe will assist in performing preliminary environmental assessment work and communicate to interested agencies and parties as appropriate. With resultant information, the Project will interactively work with tribal members and the surrounding community to receive initial public comment.

8) Corporate Structure

The Project will conduct some initial research and report on forms of potential tribal participation that best serves what the Tribe assesses as what is in its best interest. Accordingly, the Tribe will consider financing options for its desired level of participation.

9) Operations, Maintenance and Training Planning

The Project will assess and report on necessary operations, maintenance and training plans for the power plant(s) and how best the Tribe can participate according to the needs of the

Project(s). Review of potential tribal corporate structures will be conducted and those recommendations made in light of the Project structure preferred by the Tribe.

10) Infrastructure Development Planning

The Tribe will determine and report on infrastructure needed, including service roads to the turbines in the wind farm and to pumps and hydroelectric equipment, if appropriate

Section 3: Conclusions, Recommendations & Lessons Learned

1) Wind/Hydroelectric Concept Description

There has long been speculation that the lands adjacent to the Big Bend Hydroelectric Facility could take advantage of the proximity to current hydroelectric infrastructure to pursue pumped storage facilities and commercial wind development.

Although the Lower Brule Sioux Nation has painstakingly sought to clarify their legal, ancestral, and treaty rights associated with the management of the Missouri River, its facilities and its water resources, the Nation has tread carefully with respect to the wide variety of issues related to the development of any additional hydroelectric related facilities within its traditional territories. It is important to note that the rights to and over water resources are a sensitive matter and not taken lightly by any Tribal government. As this Project undertook this investigation, it did so with an watchful eye on all the technical, legal and political ramifications which are impossible to document. What has been less than clear is the opinion of the Army Corp or Western Area Power Administration towards reservoir or pumped storage development related to wind production facilities. From a tribal and customer perspective, like its power marketing counterpart Bonneville, Western and its customers would benefit greatly from a serious and deliberate look at policy towards wind and hydro integration and particularly in light of the superior rights of Indian Tribes to the water resources which flow through these facilities. What one thing that did become very clear, however, through this Project is that a wind project will benefit greatly from the proximity to the current hydroelectric facility's existing electrical transmission infrastructure (substation) at Big Bend Dam.

2) Preliminary Feasibility Determinations

Overall, the Project did examine and report to Tribal Council on each of the following feasibility determinations and a series of go/no-go analysis and reporting has been made. There were cases where initial determinations were made that proposed task/objectives were not physically, technically, legally or economically feasible so the Project ceased work on that task. For a variety of reasons, pumped storage options were deemed not feasible at the time of study to warrant a go-forward determination and thus the Tribe determined to refocus and reorganize its efforts on commercial wind development assessments.

3) Attendant Water Development/Facility Issues

The Project made a determination regarding preliminary pumped storage feasibility and a report on the technical and physical feasibility was concluded. The Tribal leadership made the strategic decision to focus its efforts on commercial wind development and until market conditions changed related to pumped storage facility costs and feasibility, this option would be periodically reviewed for any economic and/or policy changes which would make those options more viable.

4) Wind Resource and Technology Evaluation

The Tribe has fully investigated and pursued access to the transmission grid to benefit a commercial wind farm, including capacity of the transmission lines, potential marketing options, and any other related transmission issues. The Project utilized past wind data collected as support data but new data was an absolute necessity and met towers were microsited in order to assess the viability of developing a commercial wind farm. The activities undertaken and completed include wind mapping, topographical review and other state of the art wind development technical analyses. Initial identification of potential wind technology has been made.

5) Economic Feasibility

Economic analysis has been undertaken by third parties and economic models have been created to reflect various public and private financing scenarios and are currently being utilized by the Project in negotiations.

6) Political Feasibility

Numerous tribal community informational meetings were held as well as multiple and in-depth council sessions discussing issues related to business structures, self-financing alternatives, visual and cultural impacts on communities and community membership, timing and market conditions and findings of analytical studies.

7) Assessing Environmental Benefits and Impacts, and the Permitting process

A Project fatal flaw analysis was conducted related to environmental, archeological and wildlife issues of the sites where the wind farm(s) could potentially be sited. The Tribe will continue these efforts beyond this study and plans to continue with environmental assessment work and communicate to interested agencies and parties as required.

8) Corporate Structure

The Tribe considered at length the potential of public finance alternatives, including United States Department of Agricultural grants and loans as well as Clean Renewable Energy Bonding authorities. The Tribe has also conducted a legal review of existing tribal corporate entities, federally-chartered and tribally-chartered. Going forward on a project finance or other basis, the Tribe will continue consideration of financing options for its desired level of participation sized to the project(s) contemplated.

9) Operations, Maintenance and Training Planning

The Tribe anticipates that aside from its tribal employment rights ordinance requirements, training and hiring provisions negotiated related to operations, maintenance and training plans for the power plant(s) have been well considered. A preferred tribal corporate structure has been identified and considered acceptable by the Tribe.

10) Infrastructure Development Planning

Infrastructure requirements were used as a filter in relation to initial siting of various potential commercial sites so major infrastructure needs have met project needs.

Section 4: Project Plan

Results of Site-specific resource and project assessments are as follows:

1. Natural Resource Assessments

The primary resources available to the tribe that constitute renewable sources of energy are wind and water flow.

Phase I Wind and Water Assessments: 2001-2005

In the calendar year 2001, with funding from the Administration for Native Americans, the Tribe erected and monitored two anemometers, one located on a hill above the community of Lower Brule and the second on a hill above the right tailrace of the Big Bend Dam. The results from the second of these two data collection efforts that were to be the basis for the proposed feasibility study but after those data sets were compiled, it was determined that they were insufficient to base any commercial wind assessment. Data, such as it was, was collected at the Big Bend site and provided enough information to justify a focused, organized data collection effort.

Unscientific observation of the flowage when water is discharged suggested that there was sufficient force to power a turbine to create enough pumping power to raise water to the height of a reservoir (not yet built) some 500 feet above the river. A deeper analysis was warranted and was undertaken and the result of which are reported (see Appendices).

Phase II Resource Assessments: 2005-2006

After previous wind data sets were found to be insufficient, the Project and Tribal council directed that new data collection activities be undertaken under a reorganized effort and management. At that time, the Project team undertook with the advice and approval of Tribal Council initiation of a focused wind data collection and verification effort to quantify the wind resource on the Lower Brule Reservation. Preliminary wind modeling studies were

approved and conducted by a third party firm who specializes in mesoscale wind modeling. Those wind models were utilized to reconfirm and microsite optimal meteorological tower locations. Several 60 meter met towers were installed in various locations and wind data has been collected and verified since that time.

Subsequent wind data collection and analysis efforts undertaken – with advisory by and in conjunction with a third party international expert wind engineering firm – has concluded that the wind sites identified and tested can support a large scale wind development project. This effort also utilized correlative longer-term wind data obtained from a non-tribal 50 meter tower 7 kilometers away from the proposed project site, and results estimate that overall annual wind speeds from 7.8 to 8.6 m/s are present at 80 meter hub height. Since that time, data has been collected and verified at 30m, 45m N, 45m S, 60m S and 60m N with data coverage of 95-96% by the current 60 meter met towers installed. These towers continue to collect data for project development purposes. This specific data is not available for public disclosures at this time since the Tribe is in midst of negotiations.

2. Tribal Loads and Export Market – Transmission Study Work

The Lower Brule Reservation, in calendar year 2000, used approximately 8 million kilowatt-hours of electricity for a total electric cost of $620,000. It is estimated that this amount of electricity use produced 13 million pounds of carbon dioxide. Applying the Tribe's current growth rate, it is estimated that by 2010, the load is expected to be approcimately16 million kilowatt-hours of electricity at a cost of $1.3 million, producing 28 million pounds of carbon dioxide.

Among the myriad of necessary ingredients with which to develop a wind facility is the presence of suitable electrical transmission facilities with which to interconnect and transmit the electrical output of the facility. This critical path analysis is the focus of this transmission and market work. The following encapsulates a summary narrative description as well as analysis of the work initiated and *completed*:

<u>The South Dakota Transmission System - Generally</u>

The backbone of the South Dakota transmission system, particularly in the areas studied, is comprised of a large regional network of 500 kV, 345 kV and 230 kV lines and secondary systems at 69 kV –161 kV. The rural nature of South Dakota requires that most of the electrical generation in the region is transmitted to loads across long distances. Due to the fundamental nature of this system's long distance transmission lines, the stability of the system can become an issue particularly if those transmission lines are heavily loaded as operators will occasionally limit power transfers below their rated thermal transmission limits.
Three key factors for transmission interconnection options for wind facilities include:

- Physical Capability - The point of interconnection needs to be technically capable of safely absorbing the new wind facilities;
- Location - The point of interconnection needs to be as proximately situated as possible to the new wind facilities in order to minimize cost and physical transmission line losses

- Cost - An ideal interconnection location is one that can maximize the cost of interconnection and minimize line loss, thereby creating more value to the project overall.

Power Flow Analysis

The Lower Brule Wind Project(s) were modeled utilizing PowerWorld, a widely used industry power flow tool utilized in electrical transmission analysis. These runs utilized a large volume of data representing transmission and generation facilities and interconnected loads. The official Mid-Continent Area Power Pool for 2007 Summer Peak representation of the transmission network was utilized in the modeling for Lower Brule.

Thermal transmission limits were taken into consideration. During the engineering phase of the project(s), a formal stability study will be necessary. Also taking into consideration during the next-step screening work will be a study of transient and contingency scenarios.

Capacity Impacts

Briefly, impacts were studied for the 230kV Big Bend to Fort Thompson transmission facility which has a rated capacity limit of 389 MVA. Also studied were the impacts upon the three associated transformers, two 230 kV/345 kV transformers with a rated capacity limit of 250 MVA and one 230 kV/69 kV transformer with a rated capacity limit of 33 MVA. Taking into consideration Base Case and Change Case line loadings, it was concluded that interconnection to the substation is feasible.

Nodal Transmission Voltages

Also studied was the impact on nodal transmission voltages for the above mentioned transmission facilities, also utilizing Base Case and Change Case scenarios in order to ascertain impacts. In that case, all nodal transmission voltages are expected to remain within acceptable range of heir nominal values and interconnection is not expected to pose any voltage violations.

Engineering Work Undertaken

An approximation of interconnection costs, exclusive of land for associated easements was presented to the Tribe and those estimated costs are well within an acceptable range of costs to support a commercial wind project on the Lower Brule Sioux Reservation.

3. Energy Technologies Evaluated

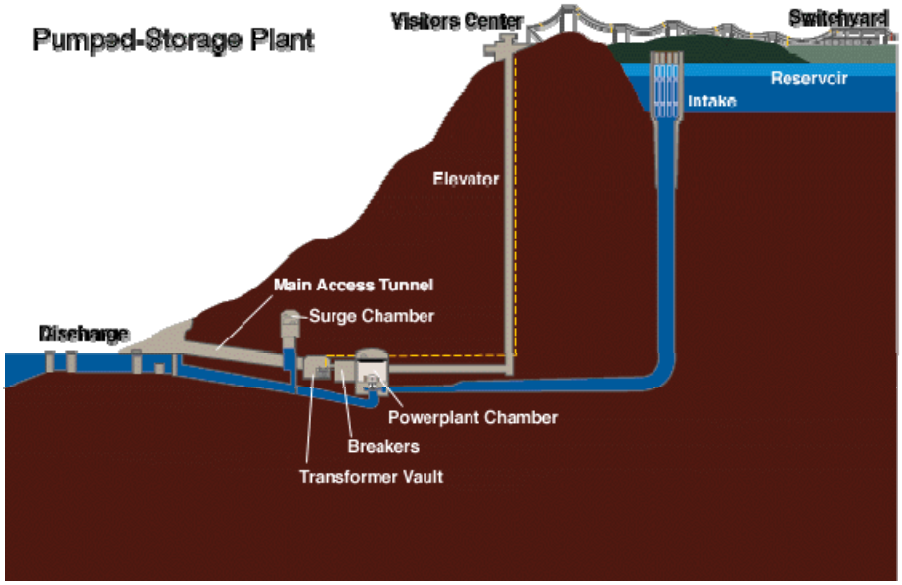
Wind Turbine

Specific turbine specifications have been identified and sized-to-resource work undertaken and completed. Due to the current nature of turbine market, the Tribe wishes to keep this analysis and selection confidential but is willing to discuss it on a case-by-case basis. Optimal

numbers, height and positioning of the turbines for a wind farm of the maximum productivity has been undertaken and presented to the Tribal Council.

Pumped Storage

The following illustration is an example of a typical pumped-storage plant.



After discussions with the Army Corp of Engineers, managers of the hydroelectric facilities in question, the Army Corp recommended the Tribe focus efforts on a closed-loop pumped storage technology/project, using two reservoirs (upper and lower) without having discharge into Lake Sharpe.

After a technical preliminary feasibility analysis, it was concluded that the topography of the tribal lands would provide insufficient net effective head required (200 feet) which would limit the output of any hydroelectric turbine to make it feasible.

4. Tribal Benefits and Barriers

The Tribe has for years considered the development of renewable energy systems that could benefit its members. The community suffered almost irreparable harm from the damming of the river and the resulting flooding of its gardens, homes and governmental infrastructure in the 1960s – without being able to enjoy any significant benefits. The present plan will hopefully be able to deliver a modicum of the benefit provided to down stream communities in the form of flood control, navigation and hydroelectric power.

The first anticipated benefit is both short-term and long-term economic improvement. Potential identified income stream would be a direct benefit to the Tribe and could help build up a development fund to pursue additional smaller-scale wind farms on the reservation that could supply power to both communities and to agricultural enterprises.

The most obvious environmental benefit of the proposed installation would be the promise of electrical power generation without depletion of the nation's (and the Tribe's) fossil-fuel resources. There would be no harmful emissions such as carbon dioxide into the atmosphere. Maintaining non-eroding channels for discharges from the reservoir would preserve the stock and quality of clean water locally.

The Tribe anticipates minimal impacts on the Tribe's culture from a project. If anything, the job opportunities resulting from a wind project could contribute to a personal sense of accomplishment for tribal workers, increased family stability and the reduction in the incidence of destructive behaviors. Many if not most of the social problems on reservations derive from poverty and unemployment.

5. Economic Viability Evaluation

This is a continuing analysis as the sizing of the project is determined. The Tribe has learned through multiple and ongoing negotiations work with potential off-takers that the market for the output of any project located on the Lower Brule Reservation is difficult but not impossible. However, it is an economic reality that without a reputable off take commitment, economic models are interesting but not absolute until energy and REC pricing is settled.

In general, however, the Tribes are acutely aware of the costs associated with pre-development, development, construction and operations of a commercial wind plant. Taking into consideration projected capacity factors, the Project has determined that installed costs are ranging from $1.47-1.6MM/MW and with increasing turbine deposit requirements; any commercial scale project has significant upfront development costs.

6. Assessing Environmental Benefits and Impacts

Preliminary environmental, archeological and wildlife fatal flaw analyses have been undertaken and that work continues for proposed project sites. Appropriate BIA Area Office personnel were briefed and consulted throughout this Project. Among the many studies which were compiled and reviewed were:

- The Environmental Assessment of the Proposed Site of the Lower Brule Sioux Tribal Justice Center
- Geotechnical Exploration, Proposed Justice Center
- Status of Mineral Resource Information for the Lower Brule Indian Reservation
- Cultural Assessment of Riparian Habitats
- Land Use History of the Armstrong Gunnery Range
- Endangered Species Report Phase I and II
- Environmental Baseline Study
- Fish Population Studies of the Missouri River
- Preliminary Assessment – Lower Brule Aquaculture Program
- Sediment Monitoring Project Study
- Survey of Medicinally Valuable Plants

- Taken Land Study Phase I Study Report
- Final EIS Title VI Land Transfer of the State of South Dakota
- Terrestrial Wildlife Habitat Restoration Plan for Oahe Reservoir

7. Barriers

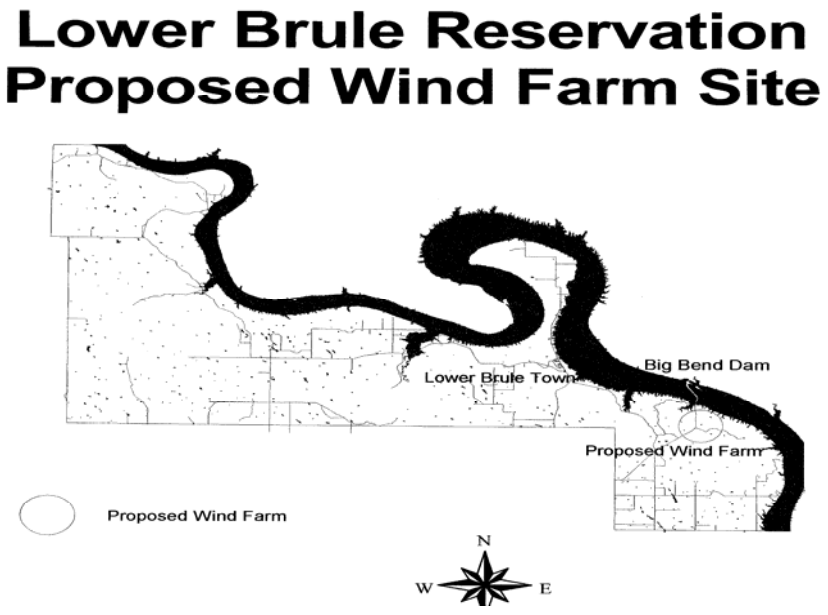
The most substantial barrier to this Project continues to be the Tribe's ability to attract and negotiate suitable credit-worthy long-term offtake agreements upon which to project finance a commercial wind project on the Lower Brule Reservation.

8. Operations and Maintenance; Training

The tribal corporation will hold the interests of the Tribe in a wind energy project. It is anticipated that it will also serve as the primary tribal management entity which will assist in the facilitation of training and hiring professional Tribal management staff and technicians to provide both regular and emergency repairs on all the equipment. The Tribe has identified specific targets for training and hiring related to wind development projects.

Section 5: Appendices

MAP OF POTENTIAL WIND FARM SITE(S)



OTHER APPENDICES

REPORT OF ACTIVITIES - Attached

PHASE I WIND DATA SUMMARY - Attached

PUMPED HYDRO TECHNICAL REPORT – Attached

Section 5 Appendices: Report of Activities

Activities Report
Lower Brule Wind-Hydro Feasibility Study

July 2004

Wind Sites & Meetings
Northwest Lower Brule Reservation
Cherry Ranh Ridge, S Hwy 1806: 50 meter met tower site
West Ft. george Butte
LB Farm Corp: No River Bluffs: Pum Storage Potential

Meetings
BIA Natural Resource Staff; topographical and land ownership maps for wind and potential pump storage sites
Environmental Dept Director and Staff: briefing on wind energy feasibility plans and preliminary environmental review including Phase I avian assessment and cultural resource review, identify staff to assist in process
Tribal Chairman/Secretary/Treasurer/Councilman: briefing on wind energy feasibility study sites and options

August 2004

Sites were identified for testing including land adjacent to the Tribal Headquarters in a land referred to as the Buffalo Pasture, which is

adjacent to the Missouri River with an elevation about 250-300 feet above the river. There is a substation across the road from the site, with a need to determine capacity of the transformer in that substation to determine current interconnection capacity.

The water flow at the tail race of the dam was found to be significant. It was reported that in order to evaluate the applicability of a run of the river hydro facility in this location, the Tribe needed to know minimum flow rates for at least five years; operational guidelines for the dam's flow control; voltage of the existing generators; and interconnection requirements to the low side of the step up transformers interconnecting to WAPA transmission lines. That information has been requested of the Army Corp and of Western.

It was also reported to the Tribe that a pumped storage facility can easily be supported by the topography near or in the Buffalo Pasture. The largest issue with this technology is determining the total storage volume in megawatt hours. It was recommended that the Tribe undertake an updated load analysis.

The rural electric cooperative was contacted for the Buffalo Pasture substation capacity and was told it was forthcoming.

The Tribal leadership response to the Buffalo Pasture sight was a certain amount of reluctance due to aesthetic reasons. Other community members were to be polled to determine any cultural or other resistance to this site.

Meetings with the Army Corp and Western were conducted but no particular project size or capacity were identified. An issue that was also raised was the need to FERC approvals for any interconnection for such a facility and there were to be further communications with the Army Corps to further explore this issue.

September 2004

Copies of wind data for the Lower Brule West site near the Tribal Headquarters and Big Bend Dam (see attached). This wind data was reformatted by Ed McCarthy, a meteorologist and the format includes data from a tower with instrumented with sensors at 30, 40 and 50 meters but without wind directional data. The data presented is reported by monthly average hourly reading. The physical data is actually recorded every fifteen minutes but for reporting purposes, the average was taken of the reading for hour #1 over the entire month. So, on page one for January, the average for the hour from 12:00 AM to 1:00 AM of 12.0 mph at the 30 meter level (upper left-hand corner) is provided. At the bottom of that column, the average (mean) for the month of January is 12.2 mph at the 30 meter level.

Preliminary summary reports were presented to the Tribe that in examining the existing 50 meter data, the identified West Brule site measures 16.2 mph and the Big Bend Site measures 16.6 mph. It was postulated at that time that the West Brule Site was the most developable due to its proximity of the Lower Brule Substation and resulting ease of interconnection. Several community meetings were held which provided general wind energy information and to answer questions or address any concerns about any potential wind site on the reservation.

During visits in this time period, it was reported to the Tribe that there was sufficient water flowing to operate a small commercial run-of-the-river hydro facility. A set of operational questions were created for the Army Corp to answer so a preliminary hydro facility could be evaluated. Preliminary evaluations have been made of technology related to pumped storage systems, which identified closed-loop pumped storage as a viable option which greatly reduced permitting requirements with the FERC. The concept as explained to the Tribe is to have a storage tank on top of a hill and a corresponding storage tank at the bottom of the hill with a hydro generator integrated into a pipe between the upper and lower tanks. When the energy has its greatest value, the water flows from the low tank through the generator, creating electricity. The FERC has indicated that such a closed-loop system may be permitted quickly. The first filling of the tanks and replenishing would come from the Missouri River.

It was related to the Tribe that the largest cost component is the storage tanks and excavated reservoirs would be must less expensive than purchasing tanks. The size of the reservoirs would be dependent upon the storage capacity that the Tribe requires. That amount will be determined as a detailed energy usage of the Tribe was undertaken.

It was recommended that a ten megawatt wind plan could be designed at either identified wind site. Further data was to be collected and analyzed in order to conduct an updated tribal load analysis to further match resource to load for a potential project.

January 2005

The Army Corp provided the following technical parameters regarding the Big Bend Dam:

- The facility is a rolled earth dam with a height of 95 feet and a total length of 10,570 feet
- The fill quantity is 17,000,000 cubic yards
- The spillway's crest length is 376 feet
- There are eight gates sized 39.1 x 40 feet
- The crest elevation is 1,385 feet msl
- The power plant includes eight generators with a capacity of 61.579 MW per unit
- The storage capacity o fthe lake above the dam is 1,910,000 acre feet with 56,884 surface acres and a length of 80 miles
- The maximum depth is 78 feet and the shoreline length is 200 miles
- This facility is used primarily as a peaking plant and a re-regulating device for the Missouri River

The following was reported regarding the Lower Brule West Substation

- It has a 7500kVA 69/14.4/24.9kV load serving transformer

- The 69kV transmission system in the region is comprised of 4/0 ACSR so the limiting thermal factor in a steady state analysis will be the Lower Brule West transformer, not the transmission system
- Depending on the identify of the power purchases and associated energy delivery point, a voltage drop and power loss analysis may be necessary and would be covered in any required interconnections tudy

The following was reported regarding pumped storage tank equipment and preliminary feasibility analysis work:

- For steel tanks that were quoted were too costly to be seriously considered, as prices ranged from $0.15 to $0.23 per gallon
- When the available head and reasonable storage size are factored in, this produces a prohibitively high power production price
- Concrete tanks may be an option as will be the possibility of a reservoir for the uphill storage facility, both requiring a more rigorous examination of FERC guidelines since there would be potential environmental concerns

2006 – Next Phase Wind Project Development and Analysis Work

As preliminary pumped storage work and analysis had not provide enough justification or rationale to pursue this as a viable alternative at the time, in 2006 the Lower Brule Sioux Tribe had made the decision to move forward and focus on the commercial development of its wind resources on the Lower Brule Sioux Reservation, one of critical path avenues that the Tribe has undertaken has been to ascertain the technical feasibility and physical requirements associated to a development of this magnitude.

Among the myriad of necessary ingredients with which to develop a wind facility is the presence of suitable electrical transmission facilities with which to interconnect and transmit the electrical output of the facility.

Activities Report
Lower Brule Wind-Hydro Feasibility Study

July 2004

Wind Sites & Meetings
Northwest Lower Brule Reservation
Cherry Ranh Ridge, S Hwy 1806: 50 meter met tower site
West Ft. george Butte
LB Farm Corp: No River Bluffs: Pum Storage Potential

Meetings
BIA Natural Resource Staff; topographical and land ownership maps for wind and potential pump storage sites
Environmental Dept Director and Staff: briefing on wind energy feasibility plans and preliminary environmental review including Phase I avian assessment and cultural resource review, identify staff to assist in process
Tribal Chairman/Secretary/Treasurer/Councilman: briefing on wind energy feasibility study sites and options

August 2004

Sites were identified for testing including land adjacent to the Tribal Headquarters in a land referred to as the Buffalo Pasture, which is adjacent to the Missouri River with an elevation about 250-300 feet above the river. There is a substation across the road from the site, with a need to determine capacity of the transformer in that substation to determine current interconnection capacity.

The water flow at the tail race of the dam was found to be significant. It was reported that in order to evaluate the applicability of a run of the river hydro facility in this location, the Tribe needed to know minimum flow rates for at least five years; operational guidelines for the dam's flow control; voltage of the existing generators; and interconnection requirements to the low side of the step up transformers interconnecting to WAPA transmission lines. That information has been requested of the Army Corp and of Western.

It was also reported to the Tribe that a pumped storage facility can easily be supported by the topography near or in the Buffalo Pasture. The largest issue

with this technology is determining the total storage volume in megawatt hours. It was recommended that the Tribe undertake an updated load analysis.

The rural electric cooperative was contacted for the Buffalo Pasture substation capacity and was told it was forthcoming.

The Tribal leadership response to the Buffalo Pasture sight was a certain amount of reluctance due to aesthetic reasons. Other community members were to be polled to determine any cultural or other resistance to this site.

Meetings with the Army Corp and Western were conducted but no particular project size or capacity were identified. An issue that was also raised was the need to FERC approvals for any interconnection for such a facility and there were to be further communications with the Army Corps to further explore this issue.

September 2004

Copies of wind data for the Lower Brule West site near the Tribal Headquarters and Big Bend Dam (see attached). This wind data was reformatted by Ed McCarthy, a meteorologist and the format includes data from a tower with instrumented with sensors at 30, 40 and 50 meters but without wind directional data. The data presented is reported by monthly average hourly reading. The physical data is actually recorded every fiftenn minutes but for reporting purposes, the average was taken of the reading for hour #1 over the entire month. So, on page one for January, the average for the hour from 12:00 AM to 1:00 AM of 12.0 mph at the 30 meter level (upper left-hand corner) is provided. At the bottom of that column, the average (mean) for the month of January is 12.2 mph at the 30 meter level.

Preliminary summary reports were presented to the Tribe that in examining the existing 50 meter data, the identified West Brule site measures 16.2 mph and the Big Bend Site measures 16.6 mph. It was postulated at that time that the West Brule Site was the most developable due to its proximity of the Lower Brule Substation and resulting ease of interconnection. Several community meetings were held which provided general wind energy information and to answer questions or address any concerns about any potential wind site on the reservation.

During visits in this time period, it was reported to the Tribe that there was sufficient water flowing to operate a small commercial run-of-the-river hydro facility. A set of operational questions were created for the Army Corp to answer so a preliminary hydro facility could be evaluated. Preliminary evaluations have been made of technology related to pumped storage systems, which identified closed-loop pumped storage as a viable option which greatly reduced permitting requirements with the FERC. The concept as explained to the Tribe is to have a storage tank on top of a hill and a corresponding storage tank at the bottom of the hill with a hydro generator integrated into a pipe between the upper and lower tanks. When the energy has its greatest value, the water flows from the low tank through the generator, creating electricity. The FERC has indicated that such a closed-loop system may be permitted quickly. The first filling of the tanks and replenishing would come from the Missouri River.

It was related to the Tribe that the largest cost component is the storage tanks and excavated reservoirs would be must less expensive than purchasing tanks. The size of the reservoirs would be dependent upon the storage capacity that the Tribe requires. That amount will be determined as a detailed energy usage of the Tribe was undertaken.

It was recommended that a ten megawatt wind plan could be designed at either identified wind site. Further data was to be collected and analyzed in order to conduct an updated tribal load analysis to further match resource to load for a potential project.

January 2005

The Army Corp provided the following technical parameters regarding the Big Bend Dam:

- The facility is a rolled earth dam with a height of 95 feet and a total length of 10,570 feet
- The fill quantity is 17,000,000 cubic yards
- The spillway's crest length is 376 feet
- There are eight gates sized 39.1 x 40 feet
- The crest elevation is 1,385 feet msl
- The power plant includes eight generators with a capacity of 61.579 MW per unit

- The storage capacity o fthe lake above the dam is 1,910,000 acre feet with 56,884 surface acres and a length of 80 miles
- The maximum depth is 78 feet and the shoreline length is 200 miles
- This facility is used primarily as a peaking plant and a re-regulating device for the Missouri River

The following was reported regarding the Lower Brule West Substation

- It has a 7500kVA 69/14.4/24.9kV load serving transformer
- The 69kV transmission system in the region is comprised of 4/0 ACSR so the limiting thermal factor in a steady state analysis will be the Lower Brule West transformer, not the transmission system
- Depending on the identify of the power purchases and associated energy delivery point, a voltage drop and power loss analysis may be necessary and would be covered in any required interconnections tudy

The following was reported regarding pumped storage tank equipment and preliminary feasibility analysis work:

- For steel tanks that were quoted were too costly to be seriously considered, as prices ranged from $0.15 to $0.23 per gallon
- When the available head and reasonable storage size are factored in, this produces a prohibitively high power production price
- Concrete tanks may be an option as will be the possibility of a reservoir for the uphill storage facility, both requiring a more rigorous examination of FERC guidelines since there would be potential environmental concerns

2006 – Next Phase Wind Project Development and Analysis Work

As preliminary pumped storage work and analysis had not provide enough justification or rationale to pursue this as a viable alternative at the time, in 2006 the Lower Brule Sioux Tribe had made the decision to move forward and focus on the commercial development of its wind resources on the Lower Brule Sioux Reservation, one of critical path avenues that the Tribe has undertaken has been to ascertain the technical feasibility and physical requirements associated to a development of this magnitude.

Among the myriad of necessary ingredients with which to develop a wind facility is the presence of suitable electrical transmission facilities with which to interconnect and transmit the electrical output of the facility. This critical path analysis is the focus of the scope of work that this report seeks to summarize. The following encapsulates a summary narrative description as well as analysis of the work initiated and completed:

Discussion

The South Dakota Transmission System - Generally

The backbone of the South Dakota transmission system, particularly in the areas studied, is comprised of a large regional network of 500 kV, 345 kV and 230 kV lines and secondary systems at 69 kV –161 kV. The rural nature of South Dakota requires that most of the electrical generation in the region is transmitted to loads across long distances. Due to the fundamental nature of this system's long distance transmission lines, the stability of the system can become an issue particularly if those transmission lines are heavily loaded as operators will occasionally limit power transfers below their rated thermal transmission limits.

Transmission Study Findings Summary – Lower Brule

Three key factors for transmission interconnection options for wind park facilities include:

1. Physical Capability. The point of interconnection needs to be technically capable of safely absorbing the new wind facilities;
2. Location. The point of interconnection needs to be as proximately situated as possible to the new wind facilities in order to minimize cost and physical transmission line losses;
3. Cost. An ideal interconnection location is one that can maximize the cost of interconnection and minimize line loss, thereby creating more value to the project overall.

The Lower Brule Wind Project(s) were modeled utilizing PowerWorld, a widely used industry power flow tool utilized in electrical transmission analysis. This modeling process utilized a large volume of data representing transmission and

generation facilities and interconnected loads. The official Mid-Continent Area Power Pool for 2007 Summer Peak representation of the transmission network was utilized in the modeling for Lower Brule.

PowerWorld was modeled for Lower Brule to establish:

- Base case conditions of the Western Area Power Administration system for Lower Brule project site(s) assessing the impact of a potential large scale generation project on the local system;

- Impacts of incremental injections on line loadings and nodal transmission voltages (a pre-injection case is utilized as the Base Case and post-injection case utilized as the Change Case);

Thermal transmission limits have been taken into consideration. During the engineering phase of the project(s), that phase of project development will entail a formal stability study. Also taking into consideration during the next-step screening analysis will be a study of transient and contingency scenarios.

Capacity Impacts

Lower Brule project(s) interconnection point modeled and studied was at the 230 kV Big Bend substation, meeting the key factors set forth for the sizing of the facilities under development, study and contemplation. Briefly, impacts were studied for the 230kV Big Bend to Fort Thompson transmission facility which has a rated capacity limit of 389 MVA. Also studied were the impacts upon the three associated transformers, two 230 kV/345 kV transformers with a rated capacity limit of 250 MVA and one 230 kV/69 kV transformer with a rated capacity limit of 33 MVA.

Taking into consideration Base Case and Change Case line loadings, it was concluded that interconnection to the substation is not only feasible but no upgrades were required of existing facilities.

Nodal Transmission Voltages

Also studied was the impact on nodal transmission voltages for the above mentioned transmission facilities, also utilizing Base Case and Change Case

scenarios in order to ascertain impacts. In that case, all nodal transmission voltages are expected to remain within acceptable range of heir nominal values and interconnection is not expected to pose any voltage violations.

Engineering and Cost Work Performed

A single line diagram of interconnection to the 230 kV Big Bend Substation was likewise prepared and submitted to Western Area Power Administration along with the formal interconnection application.

An approximation of interconnection costs, exclusive of land for associated easements. Those estimated costs are well within an acceptable range of costs to support a commercial wind project on the Lower Brule Sioux Reservation.

Wind Data Analysis Undertaken and Underway

Wind data collection and analysis efforts undertaken by the Tribe, and analyzed by a third party international wind engineering firm, along with correlative longer term wind data obtained from a non-tribal local 50 meter tower 7 kilometers away from the proposed project site, estimate that overall annual wind speeds from 7.8 to 8.6 m/s are present at 80 meter hub height. Preliminary wind modeling studies were conducted by another third party firm who specializes in mesoscale wind modeling and those models were utilized to determine optimal meteorological tower locations which were installed and data has been collected from numerous sites. Since that time, data has been collected and verified at 30m, 45m N, 45m S, 60m S and 60m N with data coverage of 95-96%, by the current 60 meter met towers installed and continue to collect data for project development purposes. This data shall remain proprietary and not available for public disclosures at this time.

Environmental Assessments Work Underway

Preliminary environmental and wildlife studies have been undertaken and are underway for proposed project sites. Among the many studies which were compiled and reviewed were:

- The Environmental Assessment of the Proposed Site of the Lower Brule Sioux Tribal Justice Center
- Geotechnical Exploration, Proposed Justice Center

- Status of Mineral Resource Information for the Lower Brule Indian Reservation
- Cultural Assessment of Riparian Habitats
- Land Use History of the Armstrong Gunnery Range
- Endangered Species Report Phase I and II
- Environmental Baseline Study
- Fish Population Studies of the Missouri River
- Preliminary Assessment – Lower Brule Aquaculture Program
- Sediment Monitoring Project Study
- Survey of Medicinally Valuable Plants
- Taken Land Study Phase I Study Report
- Final EIS Title VI Land Transfer of the State of South Dakota
- Terrestrial Wildlife Habitat Restoration Plan for Oahe Reservoir

Phase I Study of Preliminary Sites

Met Tower Data Summaries

Lower Brule Big Bend Jan 01-Aug 02

MEAN HOURLY WIND SPEEDS

LOWER BRULE SIOUX TRIBE
BIG BEND-30M WIND SPEED (MPH)

01/01/01 - 07/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	13.2	13.6	11.7	14.6	12.6	13.1	12.6	11.4	13.8	13.6	13.9	15.9	13.2
02	13.3	13.5	11.7	14.8	13.0	14.1	13.2	13.3	13.4	14.1	13.5	14.4	13.5
03	13.4	12.8	11.4	14.3	13.6	13.5	12.8	12.0	12.2	14.0	12.4	14.4	13.0
04	12.7	13.2	10.9	13.8	13.2	12.8	12.3	11.6	12.9	14.3	11.7	13.7	12.7
05	13.3	14.0	11.2	13.9	13.4	13.2	11.2	10.7	11.9	13.5	11.2	13.6	12.6
06	13.2	14.3	11.0	13.7	13.3	13.2	11.7	10.1	12.0	14.0	10.8	13.6	12.6
07	13.0	14.0	10.8	14.1	12.4	11.7	11.4	9.7	11.7	14.7	9.9	13.1	12.2
08	12.4	14.1	11.1	13.3	13.1	11.6	12.2	10.3	11.9	14.1	11.0	13.7	12.4
09	12.1	14.2	11.8	14.5	14.2	12.8	13.9	11.2	12.0	13.6	10.5	13.4	13.0
10	12.3	14.0	11.9	15.4	15.4	13.8	13.9	11.8	12.5	14.7	8.5	13.2	13.4
11	13.0	14.6	12.4	15.6	16.4	14.5	14.4	13.4	13.7	15.3	9.4	13.5	14.1
12	13.7	15.6	12.9	16.3	17.4	15.1	14.0	13.8	14.2	16.5	10.6	13.4	14.7
13	13.3	15.6	12.7	15.9	17.6	15.8	14.8	14.1	15.2	16.8	11.7	15.1	15.0
14	14.8	16.0	13.2	16.6	17.6	15.3	14.9	14.4	15.3	18.0	12.8	15.1	15.4
15	14.9	16.2	13.3	16.6	17.5	15.1	14.7	14.5	15.6	17.4	14.0	16.4	15.5
16	13.8	15.5	13.4	16.9	17.9	15.6	14.9	14.4	15.6	17.0	14.4	14.9	15.4
17	11.5	14.5	13.6	16.6	17.1	16.1	14.5	15.0	15.9	16.9	12.8	13.5	15.0
18	11.7	14.6	12.7	16.3	16.4	14.9	14.7	15.1	15.4	15.6	12.0	12.1	14.5
19	11.8	14.1	12.0	15.6	15.4	14.2	14.0	15.2	14.7	13.8	12.6	13.2	14.0
20	11.9	13.5	11.7	13.4	14.8	13.0	12.9	13.1	14.6	13.5	13.1	12.6	13.1
21	11.9	13.1	12.0	14.0	13.4	12.5	12.4	12.4	14.2	13.9	13.4	14.7	13.1
22	11.6	13.3	11.7	14.5	13.6	14.1	12.0	12.5	14.9	15.3	13.2	15.0	13.4
23	12.2	13.4	12.0	15.1	13.6	14.0	12.4	13.1	14.3	14.9	13.4	14.8	13.6
24	11.3	13.8	11.8	14.6	13.1	13.4	12.2	12.6	13.6	14.5	13.2	15.9	13.3
Mean	12.7	14.2	12.0	15.0	14.8	13.9	13.3	12.7	13.8	15.0	12.1	14.1	13.7
Good Hours	526	1260	1488	1319	1060	1166	1214	744	720	744	612	695	
Missing Hours	962	84	0	121	428	274	274	0	0	0	108	49	

11,548 Hours of Good Data 2,300 Hours Missing 83.4% Data Recovery

Lower Brule Big Bend Jan 01-Aug 02

MEAN HOURLY WIND SPEEDS

LOWER BRULE SIOUX TRIBE
BIG BEND-40M WIND SPEED (MPH)

01/01/01 - 07/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	14.3	14.7	12.8	15.7	13.6	14.2	13.5	12.4	15.0	14.9	15.2	17.3	14.4
02	14.5	14.7	12.8	15.9	14.0	15.1	14.1	14.3	14.4	15.6	14.9	15.9	14.6
03	14.7	13.9	12.5	15.5	14.8	14.5	13.7	13.1	13.2	15.3	13.6	15.4	14.1
04	14.2	14.4	12.0	15.1	14.3	13.7	13.3	12.6	13.7	15.6	12.7	15.0	13.8
05	14.6	15.2	12.2	15.1	14.5	14.4	12.2	11.8	12.8	14.8	12.7	14.6	13.7
06	14.6	15.5	12.2	14.7	14.3	14.1	12.7	11.2	12.9	15.3	11.6	14.7	13.7
07	14.2	15.3	11.9	15.1	13.4	12.6	12.3	10.7	12.5	15.9	10.8	14.3	13.3
08	13.7	15.3	12.0	14.4	13.8	12.1	12.7	11.1	12.7	15.4	12.2	14.8	13.4
09	13.4	15.4	12.5	15.2	14.8	13.1	14.4	11.5	12.4	14.9	11.7	14.6	13.8
10	13.6	14.8	12.5	15.9	15.9	14.1	14.2	12.0	12.7	15.3	9.6	14.4	14.0
11	13.8	15.1	12.9	16.2	17.0	14.7	14.6	13.6	13.9	15.7	10.0	14.3	14.5
12	14.2	16.2	13.4	16.7	17.9	15.4	14.2	14.1	14.6	17.0	10.9	14.1	15.1
13	13.9	16.1	13.2	16.3	18.2	16.2	15.1	14.3	15.6	17.5	12.2	15.8	15.5
14	15.2	16.5	13.7	17.2	18.3	15.6	15.1	14.5	15.6	18.6	13.2	15.7	15.8
15	15.4	16.8	13.8	17.1	18.2	15.4	15.0	14.7	16.1	18.0	14.3	16.9	16.0
16	14.3	16.1	14.0	17.4	18.6	16.0	15.0	14.8	16.0	17.7	14.9	15.3	15.9
17	12.1	15.2	14.3	17.3	17.8	16.5	14.9	15.3	16.4	17.7	13.3	14.2	15.6
18	12.4	15.5	13.6	17.0	17.0	15.3	15.0	15.5	15.9	16.5	12.9	13.2	15.2
19	12.7	15.2	13.2	16.4	16.0	14.6	14.4	15.8	15.4	15.1	13.5	14.4	14.8
20	13.0	14.9	12.9	14.4	15.8	13.6	13.6	13.9	15.7	14.9	14.1	13.8	14.2
21	12.8	14.3	13.1	15.2	14.6	13.4	13.4	13.5	15.3	15.1	14.5	15.9	14.2
22	12.9	14.3	12.9	15.8	14.8	15.3	13.0	13.6	15.8	16.6	14.4	16.3	14.6
23	13.2	14.5	13.2	16.4	14.8	15.2	13.3	14.1	15.4	16.2	14.8	16.1	14.7
24	12.2	15.1	13.0	15.8	14.1	14.4	13.1	13.5	14.8	16.2	14.5	17.4	14.4
Mean	13.7	15.2	13.0	15.9	15.7	14.6	13.9	13.4	14.5	16.1	13.0	15.2	14.6

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Good Hours	526	1259	1437	1319	1060	1166	1214	744	720	744	612	695
Missing Hours	962	85	51	121	428	274	274	0	0	0	108	49

11,496 Hours of Good Data 2,352 Hours Missing 83.0% Data Recovery

Lower Brule Big Bend Jan 01-Aug 02

LOWER BRULE SIOUX TRIBE
BIG BEND-40M WIND SPEED (MPH)

01/01/01 - 07/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	15.1	15.5	13.3	16.5	14.4	15.1	14.4	13.3	16.0	15.7	16.3	18.3	15.2
02	15.3	15.8	13.3	16.8	14.7	15.9	15.0	15.2	15.4	16.8	16.3	16.7	15.5
03	15.5	14.9	13.1	16.4	15.5	15.2	14.7	13.9	14.1	16.3	14.7	16.1	15.0
04	15.3	15.4	12.5	16.0	15.0	14.5	14.2	13.6	14.4	16.7	13.6	15.7	14.7
05	15.3	16.1	12.7	15.8	15.2	15.3	13.2	12.7	13.6	16.0	14.1	15.6	14.6
06	15.5	16.2	12.7	15.4	15.1	15.0	13.4	12.1	13.7	16.1	12.7	15.5	14.5
07	15.4	16.1	12.5	15.6	14.2	13.4	13.0	11.7	13.3	16.7	11.8	15.1	14.1
08	14.9	16.4	12.6	15.1	14.3	12.5	13.2	11.8	13.5	16.3	13.0	15.7	14.1
09	14.3	16.3	12.9	15.5	15.0	13.2	14.8	11.7	13.0	16.0	12.5	15.6	14.3
10	14.5	15.5	12.6	16.1	16.0	14.2	14.5	12.2	12.8	15.7	10.5	15.4	14.3
11	14.4	15.2	12.9	16.1	17.2	14.9	14.9	13.7	14.0	15.8	10.4	15.0	14.7
12	14.8	16.1	13.4	17.0	18.1	15.4	14.4	14.2	14.6	17.1	11.1	14.4	15.2
13	14.3	16.1	13.2	16.5	18.4	16.3	15.3	14.6	15.8	17.5	12.2	16.1	15.6
14	15.5	16.7	13.7	17.4	18.3	15.7	15.3	14.8	15.8	18.8	13.4	15.9	16.0
15	15.7	17.0	13.8	17.3	18.3	15.5	15.2	14.9	16.2	18.2	14.5	17.1	16.1
16	14.6	16.6	14.1	17.6	18.8	16.1	15.2	14.9	16.2	17.9	15.0	15.5	16.1
17	12.6	15.5	14.5	17.5	18.0	16.8	15.1	15.4	16.6	18.0	13.7	14.6	15.8
18	13.0	16.0	13.8	17.3	17.2	15.6	15.2	15.7	16.0	17.0	13.4	13.9	15.5
19	13.4	15.9	13.6	16.8	16.3	15.0	14.7	16.2	15.9	15.9	14.4	15.3	15.3
20	13.6	15.6	13.4	15.1	16.3	14.1	14.1	14.7	16.5	15.7	14.8	14.6	14.8
21	13.6	15.2	13.8	16.2	15.4	14.1	14.4	14.5	16.1	16.0	15.2	16.6	15.0
22	13.6	15.2	13.4	16.8	15.8	16.2	14.0	14.8	16.7	17.4	15.4	17.3	15.5
23	14.1	15.4	13.6	17.4	15.6	16.2	14.2	15.2	16.3	17.0	16.0	17.1	15.6
24	13.0	16.0	13.4	16.7	15.0	15.4	14.1	14.6	15.7	17.0	15.5	18.6	15.3
Mean	14.4	15.9	13.3	16.5	16.2	15.1	14.4	14.0	15.1	16.7	13.8	15.9	15.1
Good Hours	526	1252	1488	1319	1060	1166	1214	744	720	744	612	695	
Missing Hours	962	92	0	121	428	274	274	0	0	0	108	49	

11,540 Hours of Good Data 2,308 Hours Missing 83.3% Data Recovery

MEAN HOURLY WIND SPEEDS

LOWER BRULE SIOUX TRIBE
BIG BEND-50M WIND SPEED (MPH)

Lower Brule Big Bend Jan 01-Aug 02

01/01/01 - 07/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	16.0	16.5	14.3	17.4	15.6	16.6	16.1	14.9	17.1	17.0	18.1	19.6	16.4
02	16.1	16.9	14.3	17.7	15.9	17.6	16.8	16.6	16.5	18.1	18.0	17.7	16.7
03	16.3	16.3	14.0	17.4	16.7	16.8	16.7	15.1	15.1	17.5	16.3	17.3	16.2
04	16.2	16.9	13.4	17.0	16.1	15.9	16.0	15.1	15.5	18.2	14.8	17.0	15.9
05	16.0	17.6	13.6	16.9	16.5	16.4	14.6	14.0	14.6	17.1	15.7	16.6	15.8
06	16.4	17.3	13.5	16.5	16.3	16.6	14.8	13.2	15.3	16.9	14.0	16.6	15.6
07	16.4	17.4	13.4	16.8	15.4	15.1	14.2	12.6	14.7	17.7	13.2	16.3	15.3
08	15.8	17.5	13.8	15.9	15.2	13.6	14.3	12.8	14.5	17.6	14.1	16.8	15.1
09	15.0	17.3	13.7	16.1	15.9	13.9	15.5	12.4	13.8	17.4	13.9	16.6	15.2
10	15.2	16.7	13.2	16.5	16.8	14.9	15.0	12.7	13.4	16.5	12.0	16.5	15.1
11	15.4	15.8	13.4	16.5	18.0	15.6	15.4	14.2	14.7	16.9	11.4	16.1	15.4
12	15.4	16.8	13.8	17.5	18.8	16.1	15.0	14.6	15.2	18.0	11.6	15.2	15.8
13	14.9	16.9	13.6	17.2	19.1	16.9	15.8	14.9	16.3	18.2	12.7	16.8	16.2
14	16.2	17.3	14.1	17.9	19.0	16.4	16.0	15.4	16.5	19.4	13.8	16.5	16.6
15	16.5	17.5	14.1	17.7	19.0	16.4	15.8	15.5	17.0	18.9	15.0	18.0	16.7
16	15.4	17.1	14.6	18.1	19.4	16.9	16.0	15.4	16.9	18.7	15.6	16.4	16.7
17	13.3	16.1	14.9	18.0	18.7	17.6	15.8	16.1	17.2	19.0	14.5	15.6	16.5
18	13.8	16.8	14.5	17.9	18.0	16.5	16.0	16.3	16.8	18.2	14.6	15.0	16.3
19	14.1	16.8	14.4	17.5	17.2	16.0	15.6	16.9	17.1	17.2	15.8	16.3	16.3
20	14.4	16.5	14.3	16.1	17.5	15.3	15.3	15.7	18.0	16.8	16.3	15.8	15.9
21	14.6	16.2	14.9	17.4	16.9	15.7	15.6	16.1	17.6	17.0	16.5	17.9	16.3
22	14.5	16.3	14.4	18.2	17.0	17.6	15.5	16.6	18.0	18.6	16.8	18.6	16.7
23	15.3	16.3	14.6	18.7	16.7	17.7	15.8	16.7	17.6	18.2	17.5	18.4	16.9
24	14.2	16.8	14.4	17.6	16.0	16.7	15.8	16.0	17.0	18.0	17.1	20.0	16.5
Mean	15.3	16.8	14.1	17.3	17.1	16.2	15.6	15.0	16.1	17.8	15.0	17.0	16.1
Good Hours	526	1258	1477	1325	1060	1166	1214	744	720	744	612	695	
Missing Hours	962	86	11	115	428	274	274	0	0	0	108	49	

11,541 Hours of Good Data 2,307 Hours Missing 83.3% Data Recovery

MEAN HOURLY WIND SPEEDS

LOWER BRULE SIOUX TRIBE
BIG BEND-50M WIND SPEED (MPH)

01/01/01 - 07/31/02

Lower Brule Big Bend Jan 01-Aug 02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	16.4	17.0	14.5	17.9	16.1	17.1	17.0	15.7	18.2	17.6	18.5	19.9	17.0
02	16.6	17.3	14.6	18.2	16.4	17.8	17.5	17.0	17.6	18.8	18.4	18.3	17.2
03	16.9	16.7	14.3	18.0	17.2	17.2	17.1	15.5	16.1	18.3	16.5	17.6	16.7
04	16.8	17.1	13.7	17.8	16.6	16.2	16.6	15.6	16.3	19.0	15.1	17.4	16.4
05	16.7	17.8	14.0	17.5	17.0	16.8	15.2	14.6	15.3	17.8	16.0	17.2	16.3
06	17.1	17.6	14.0	17.1	16.9	16.9	15.3	13.8	15.9	17.5	14.4	17.1	16.1
07	17.0	17.8	13.9	17.2	15.8	15.5	14.5	13.4	15.2	18.4	13.4	16.8	15.7
08	16.5	18.1	14.4	16.4	15.7	13.8	15.0	13.2	15.4	18.2	14.2	17.3	15.6
09	15.6	17.9	14.2	16.5	16.3	14.2	16.0	12.8	14.3	18.0	14.0	17.1	15.6
10	15.8	17.3	13.6	17.2	17.0	15.2	15.3	13.4	13.8	16.9	12.0	16.9	15.5
11	15.8	16.5	13.8	16.9	18.3	15.9	16.0	14.8	15.2	17.3	11.3	16.4	15.8
12	15.7	17.2	14.2	18.1	19.1	16.6	15.6	15.4	15.4	18.4	11.5	15.7	16.2
13	15.2	17.2	14.0	17.7	19.4	17.5	16.3	15.8	17.0	18.5	12.6	17.3	16.6
14	16.3	17.8	14.4	18.2	19.3	16.8	16.4	16.4	17.3	19.7	13.8	17.0	17.0
15	16.7	18.0	14.5	17.9	19.3	16.7	16.1	16.1	17.7	19.2	15.1	18.4	17.1
16	15.8	17.5	14.9	18.5	19.7	17.2	16.5	16.2	17.6	19.1	15.8	16.6	17.2
17	13.7	16.6	15.4	18.3	19.1	18.1	16.1	16.9	17.6	19.4	14.8	15.7	16.9
18	13.8	17.2	15.0	18.3	18.4	17.0	16.5	17.2	17.3	18.5	15.0	15.1	16.7
19	14.3	17.3	14.9	17.9	17.7	16.8	16.2	18.1	17.7	17.7	15.8	16.7	16.8
20	14.8	17.0	14.9	16.8	18.0	16.0	16.0	17.0	18.6	17.4	15.8	16.3	16.5
21	15.0	16.7	15.3	18.0	17.5	16.6	16.8	17.2	18.2	17.6	16.3	18.4	16.9
22	14.7	16.8	14.8	18.9	17.6	18.7	16.4	17.8	18.9	18.9	16.9	19.0	17.4
23	15.8	16.9	14.8	19.5	17.5	18.5	16.8	18.0	18.5	18.6	17.9	18.7	17.5
24	14.6	17.5	14.6	18.2	16.8	17.5	16.8	17.3	18.0	18.7	17.4	20.5	17.2
Mean	15.7	17.3	14.5	17.8	17.6	16.7	16.2	15.8	16.8	18.3	15.1	17.4	16.6
Good Hours	526	1247	1488	1323	1060	1166	1214	744	720	744	612	695	
Missing Hours	962	97	0	117	428	274	274	0	0	0	108	49	

11,539 Hours of Good Data 2,309 Hours Missing 83.3% Data Recovery

MEAN HOURLY WIND SPEEDS

LOWER BRULE SIOUX TRIBE
WEST BRULE-30M WIND SPEED (MPH)

01/01/01 - 07/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	12.0	13.4	11.9	13.6	12.4	12.1	11.7	11.9	13.2	13.5	13.8	***	12.6
02	12.3	14.4	11.6	14.0	13.1	13.4	12.3	12.2	12.6	12.9	13.7	***	13.0
03	12.5	13.8	11.8	13.6	13.2	12.1	11.2	12.0	12.1	13.4	12.6	***	12.6
04	12.8	13.0	11.5	13.9	12.9	12.3	11.6	10.7	12.0	14.2	12.3	***	12.5
05	12.5	13.7	10.9	14.2	12.5	12.3	11.0	10.4	11.3	13.3	11.9	***	12.2
06	12.5	12.8	10.7	13.7	13.1	11.9	10.7	10.5	11.6	13.7	11.0	***	12.0
07	12.3	13.9	10.9	13.7	12.7	11.0	10.6	10.2	11.7	13.5	11.6	***	12.0
08	12.4	13.5	11.0	13.9	12.4	11.0	11.3	10.0	10.7	13.9	12.5	***	12.1
09	11.8	13.8	11.0	14.8	14.0	12.3	13.1	11.4	11.7	12.7	12.6	***	12.7
10	11.9	13.7	12.2	15.0	15.8	13.2	13.6	12.9	11.9	14.9	10.5	***	13.4
11	12.0	14.5	12.6	15.3	16.8	13.9	13.5	13.7	12.7	15.0	10.5	***	13.9
12	13.3	15.0	13.1	15.9	17.2	14.6	13.8	14.0	13.8	15.8	11.7	***	14.5
13	13.2	15.7	13.0	16.0	17.0	15.3	14.3	13.6	15.1	16.5	12.3	***	14.8
14	13.7	16.1	13.5	16.2	17.2	15.2	14.7	13.6	14.9	17.0	12.3	***	15.1
15	13.2	16.1	13.3	15.9	16.9	14.6	15.2	14.0	15.2	17.5	13.3	***	15.1
16	12.2	15.5	13.6	16.4	16.9	15.0	15.0	14.1	14.6	16.1	13.2	***	14.9
17	11.5	14.5	13.8	16.1	15.9	15.4	14.6	14.5	14.6	15.5	12.7	***	14.6
18	11.4	13.4	12.2	15.4	14.9	14.0	14.5	14.3	14.6	13.9	11.6	***	13.8
19	11.6	13.8	12.2	14.7	14.7	14.0	13.8	14.3	13.8	12.8	12.2	***	13.5
20	12.0	13.1	11.9	13.1	13.6	12.4	12.9	12.5	13.6	12.6	12.3	***	12.7
21	11.7	12.8	11.7	13.6	12.6	12.0	12.4	12.1	13.7	12.5	13.1	***	12.5
22	12.1	13.4	12.2	13.9	12.5	13.5	12.3	11.8	14.1	13.1	13.6	***	12.9
23	11.0	13.6	11.9	13.9	12.6	12.3	11.7	12.0	13.0	13.7	13.8	***	12.7
24	11.6	13.8	11.8	13.5	13.0	12.6	12.6	12.2	12.8	13.5	14.0	***	12.8
Mean	12.2	14.1	12.1	14.6	14.3	13.2	12.9	12.5	13.1	14.2	12.5	***	13.3
Good Hours	774	1221	1454	1351	1060	1166	1249	744	720	744	553	0	
Missing Hours	714	123	34	89	428	274	239	0	0	0	167	744	

11,036 Hours of Good Data 2,812 Hours Missing 79.7% Data Recovery

Lower Brule West Jan-01-Aug 1-02

MEAN HOURLY WIND SPEEDS

LOWER BRULE SIOUX TRIBE
WEST BRULE-40M WIND SPEED (MPH)

01/01/01 - 07/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	13.0	14.4	12.7	14.6	13.3	13.1	12.5	12.5	14.2	14.5	14.9	***	13.5
02	13.6	15.3	12.3	15.0	14.2	14.3	13.0	13.0	13.5	13.9	14.8	***	13.9
03	13.7	14.8	12.4	14.3	14.2	13.1	11.9	12.7	13.0	14.6	13.7	***	13.5
04	14.0	13.9	12.2	14.5	14.1	13.0	12.2	11.6	12.9	15.4	13.2	***	13.3
05	13.6	14.5	11.8	14.8	13.3	13.2	11.8	11.1	12.1	14.2	12.7	***	13.0
06	13.6	13.7	11.3	14.3	14.1	12.8	11.2	11.3	12.4	14.7	12.0	***	12.8
07	13.4	14.9	11.6	14.5	13.5	11.8	11.3	10.8	12.3	14.4	12.2	***	12.8
08	13.3	14.5	11.8	14.8	12.9	11.4	11.8	10.4	11.5	15.0	13.1	***	12.8
09	12.7	14.6	11.8	15.3	14.3	12.8	13.6	11.7	11.9	13.6	13.8	***	13.4
10	13.1	14.4	12.6	15.5	16.2	13.6	14.0	12.9	12.2	15.3	11.2	***	13.9
11	12.8	14.9	12.9	15.9	17.3	14.1	13.6	13.6	12.8	15.3	10.7	***	14.2
12	14.0	15.3	13.3	16.3	17.6	14.8	13.9	14.2	14.0	16.0	11.9	***	14.8
13	13.6	16.0	13.1	16.5	17.5	15.6	14.4	13.5	15.4	16.7	12.4	***	15.1
14	14.2	16.5	13.9	16.7	17.6	15.4	14.8	13.7	15.1	17.2	12.5	***	15.4
15	13.6	16.8	13.7	16.4	17.5	14.8	15.3	13.8	15.5	17.8	13.4	***	15.4
16	12.8	16.1	14.1	16.9	17.3	15.2	14.9	14.2	14.7	16.5	13.7	***	15.3
17	12.2	14.9	14.3	16.8	16.3	15.8	14.7	14.4	15.0	16.0	13.4	***	15.1
18	12.1	14.0	12.9	16.1	15.4	14.4	14.6	14.5	14.9	14.5	12.3	***	14.3
19	12.2	14.6	13.1	15.5	15.2	14.5	14.0	14.7	14.5	13.6	12.7	***	14.2
20	12.7	13.9	12.9	14.0	14.4	12.9	13.4	13.1	14.5	13.4	13.0	***	13.5
21	12.6	13.7	12.7	14.7	13.3	12.7	13.2	12.9	14.7	13.4	13.7	***	13.4
22	12.8	14.3	13.0	15.0	13.4	14.4	13.0	12.5	15.1	14.0	14.1	***	13.8
23	11.7	14.5	12.6	15.0	13.5	13.2	12.5	12.7	13.8	14.7	14.8	***	13.5
24	12.4	14.9	12.6	14.4	13.8	13.6	13.4	12.8	13.7	14.6	15.2	***	13.7
Mean	13.1	14.8	12.7	15.3	15.0	13.8	13.3	12.9	13.7	15.0	13.1	***	13.9

Good Hours												
756	1218	1458	1334	1060	1166	1249	744	720	744	553	0	

Missing Hours												
732	126	30	106	428	274	239	0	0	0	167	744	

11,002 Hours of Good Data 2,846 Hours Missing 79.4% Data Recovery

Lower Brule West Jan-01-Aug 1-02
WEST BRULE-40M WIND SPEED (MPH)

01/01/01 - 07/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	14.0	15.3	13.2	15.3	14.1	14.2	13.6	13.7	14.9	15.6	15.8	***	14.4
02	14.5	16.3	12.7	15.8	14.9	15.5	14.0	14.1	14.2	14.9	15.8	***	14.7
03	14.7	15.7	12.9	15.1	15.1	13.9	12.9	13.9	13.7	15.3	14.4	***	14.3
04	14.8	14.9	12.6	15.4	14.8	14.0	13.3	12.6	13.5	16.4	13.7	***	14.2
05	14.6	15.4	12.4	15.8	14.1	14.3	12.6	12.1	12.9	14.8	13.2	***	13.9
06	14.6	14.5	11.9	15.1	14.8	13.8	11.9	12.0	13.2	15.3	13.1	***	13.6
07	14.4	15.8	12.1	15.2	14.4	12.6	12.0	11.6	13.2	15.1	12.9	***	13.6
08	14.4	15.4	12.1	15.4	13.3	12.1	12.2	11.2	12.2	15.7	13.7	***	13.4
09	13.7	15.4	12.1	15.8	14.8	13.0	13.7	12.2	12.6	14.4	14.1	***	13.8
10	14.1	15.2	12.7	15.9	16.6	13.9	14.1	13.4	12.6	15.5	11.8	***	14.3
11	13.6	15.3	13.0	16.1	17.8	14.7	14.0	14.2	13.3	15.7	10.9	***	14.6
12	14.5	15.8	13.7	16.7	18.2	15.4	14.3	14.6	14.4	16.6	12.0	***	15.2
13	14.3	16.4	13.6	16.9	18.1	16.2	15.0	14.0	15.8	17.3	12.5	***	15.6
14	14.8	17.1	14.1	16.9	18.2	16.1	15.3	14.1	15.5	17.8	12.6	***	15.8
15	14.2	17.4	13.8	16.7	18.0	15.4	15.8	14.6	16.0	18.2	13.7	***	15.9
16	13.4	16.7	14.2	17.2	18.2	15.9	15.6	14.8	15.4	17.1	14.0	***	15.8
17	12.9	15.7	14.6	17.2	17.1	16.5	15.4	15.2	15.6	16.8	13.9	***	15.7
18	13.1	14.8	13.2	16.6	16.2	15.2	15.2	15.2	15.8	15.6	13.2	***	15.0
19	13.3	15.6	13.5	16.2	16.1	15.3	14.8	15.5	15.6	14.8	14.1	***	15.0
20	13.6	15.0	13.3	14.9	15.5	14.1	14.4	14.1	16.0	14.6	14.4	***	14.5
21	13.6	14.7	13.3	15.8	14.6	14.1	14.2	14.3	15.9	14.3	14.7	***	14.5
22	13.7	15.2	13.7	16.1	14.5	15.7	14.3	13.8	16.2	14.9	15.2	***	14.8
23	12.8	15.3	13.3	16.0	14.6	14.2	13.5	14.0	14.9	15.6	15.9	***	14.5
24	13.5	15.6	13.2	15.2	15.0	14.6	14.4	14.0	14.7	15.6	16.2	***	14.6
Mean	13.9	15.6	13.1	16.0	15.8	14.6	14.0	13.7	14.5	15.7	13.8	***	14.7
Good Hours	762	1204	1483	1327	1060	1166	1249	744	720	744	553	0	
Missing Hours	726	140	5	113	428	274	239	0	0	0	167	744	

11,012 Hours of Good Data 2,836 Hours Missing 79.5% Data Recovery

MEAN HOURLY WIND SPEEDS

LOWER BRULE SIOUX TRIBE
WEST BRULE-50M WIND SPEED (MPH)

01/01/01 - 07/31/02

Lower Brule West Jan-01-Aug 1-02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	15.9	17.2	14.8	17.2	15.9	16.1	15.6	15.5	16.7	17.4	18.1	***	16.3
02	16.3	18.6	14.4	17.8	16.8	17.3	16.1	15.9	15.9	16.6	18.1	***	16.7
03	16.6	17.9	14.3	17.0	16.8	15.9	15.0	15.6	15.6	17.3	16.6	***	16.2
04	16.3	17.0	14.0	16.9	16.9	15.9	15.4	14.0	15.1	18.4	15.4	***	15.9
05	16.5	17.5	13.9	17.4	16.1	16.2	14.8	13.6	14.5	16.5	15.5	***	15.7
06	16.6	16.2	13.3	16.6	16.8	15.7	13.6	13.5	14.9	16.8	15.0	***	15.3
07	16.6	17.6	13.6	16.7	16.3	14.3	13.4	13.0	14.9	17.2	14.7	***	15.3
08	16.3	17.3	13.6	16.6	14.9	13.3	13.4	12.3	13.7	17.6	15.2	***	14.9
09	15.6	17.4	13.4	16.8	16.1	14.1	14.7	13.0	13.6	16.2	15.5	***	15.1
10	16.0	17.0	13.5	16.8	18.0	14.8	15.1	14.2	13.2	17.0	13.2	***	15.5
11	15.4	16.5	13.7	16.7	19.2	15.6	14.9	15.2	14.0	16.8	11.6	***	15.6
12	15.9	16.9	14.4	17.7	19.4	16.3	15.1	15.5	15.1	17.7	12.7	***	16.2
13	15.3	17.4	14.5	17.9	19.4	17.1	15.8	15.0	16.6	18.2	13.0	***	16.5
14	16.1	18.1	15.0	17.9	19.3	17.0	16.1	15.2	16.2	18.8	13.1	***	16.8
15	15.6	18.4	14.6	17.7	19.3	16.2	16.7	15.6	16.8	19.2	14.4	***	16.8
16	14.7	17.8	15.2	18.1	19.3	16.7	16.6	15.8	16.4	18.2	14.7	***	16.8
17	14.2	16.9	15.8	18.2	18.3	17.6	16.5	16.2	16.8	18.2	15.0	***	16.8
18	14.6	16.2	14.6	17.9	17.5	16.4	16.4	16.5	17.3	17.2	14.8	***	16.3
19	14.8	17.0	15.0	18.0	17.7	16.8	16.2	17.1	17.6	16.8	15.8	***	16.6
20	15.3	16.4	14.8	16.8	17.6	15.9	16.1	16.3	18.6	16.8	16.2	***	16.3
21	15.1	16.3	14.8	18.1	16.7	16.3	16.3	17.0	18.2	16.3	16.0	***	16.4
22	15.1	16.5	15.3	18.3	16.6	18.1	16.8	16.1	18.3	16.9	16.8	***	16.8
23	14.8	17.0	14.9	18.2	16.7	16.4	15.7	16.1	16.7	17.3	17.7	***	16.4
24	15.4	17.4	14.6	17.1	17.1	16.5	16.8	16.0	16.6	17.1	18.2	***	16.5
Mean	15.6	17.2	14.4	17.4	17.4	16.1	15.6	15.2	16.0	17.4	15.3	***	16.2

Good Hours												
758	1191	1479	1334	1060	1166	1249	744	720	744	553	0	

Missing Hours												
730	153	9	106	428	274	239	0	0	0	167	744	

10,998 Hours of Good Data 2,850 Hours Missing 79.4% Data Recovery

MEAN HOURLY WIND SPEEDS

LOWER BRULE SIOUX TRIBE
WEST BRULE-50M WIND SPEED (MPH)

01/01/01 - 07/31/02

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	16.5	14.6	12.0	15.7	14.4	15.2	13.7	14.4	15.8	16.7	17.2	***	15.0
02	16.2	15.8	11.5	16.3	15.3	15.5	12.8	15.1	15.1	15.9	17.5	***	15.0

Lower Brule West Jan-01-Aug 1-02

03	17.0	15.0	12.2	16.7	15.3	15.2	12.5	14.8	14.7	16.5	15.9	***	14.9
04	16.7	14.1	12.2	17.1	15.4	14.9	12.6	13.6	14.4	17.4	14.7	***	14.8
05	16.5	14.8	11.5	17.4	14.4	16.3	12.9	13.1	13.7	15.7	14.6	***	14.5
06	16.9	13.3	11.0	16.7	14.9	15.3	12.5	13.1	14.0	16.2	14.2	***	14.3
07	17.3	15.8	11.9	15.8	15.2	13.7	12.4	12.3	13.7	16.2	13.8	***	14.2
08	17.5	14.9	11.6	16.6	14.0	12.0	13.0	11.6	13.0	16.9	14.4	***	13.9
09	15.8	15.3	11.5	17.0	15.2	12.5	13.8	12.4	12.9	15.4	14.6	***	14.1
10	15.9	14.8	11.9	16.3	17.1	13.9	14.0	13.3	12.6	16.1	12.5	***	14.4
11	15.9	14.4	11.9	16.9	17.6	14.6	13.4	14.1	13.2	15.8	11.2	***	14.5
12	17.6	15.2	12.5	17.5	18.3	16.0	14.1	14.5	14.5	16.6	12.2	***	15.3
13	16.0	15.3	12.2	18.0	18.1	16.3	14.0	13.9	15.8	17.4	12.6	***	15.5
14	16.0	15.3	12.5	18.3	18.4	16.0	14.7	14.1	15.7	18.0	12.8	***	15.7
15	16.2	14.8	12.0	17.8	18.6	15.7	15.3	14.3	16.2	18.6	13.8	***	15.8
16	15.7	13.3	12.9	18.4	18.3	16.9	14.8	14.7	15.2	17.5	14.3	***	15.7
17	15.0	12.3	14.0	18.3	16.9	17.4	14.3	15.0	15.9	17.2	14.3	***	15.6
18	16.0	12.8	12.1	17.7	16.1	15.3	13.9	15.2	16.0	16.3	13.6	***	15.0
19	15.8	13.6	13.3	17.8	16.2	16.0	13.6	15.8	16.2	15.8	14.5	***	15.4
20	16.6	13.8	13.0	15.9	15.8	14.5	13.5	15.1	17.0	15.8	15.1	***	15.1
21	16.3	14.0	13.0	17.0	14.6	15.3	13.8	15.3	17.0	15.2	15.4	***	15.1
22	16.2	14.1	11.8	17.4	14.5	16.5	14.0	15.0	17.4	15.9	16.0	***	15.3
23	15.8	14.1	12.1	16.7	14.6	15.0	13.3	14.8	15.9	16.7	17.0	***	15.0
24	16.9	14.6	12.1	15.4	14.6	15.5	14.2	15.0	15.8	16.4	17.4	***	15.2
Mean	16.3	14.4	12.2	17.0	16.0	15.2	13.6	14.2	15.1	16.5	14.6	***	15.0

Good Hours

389	543	736	697	744	719	744	744	720	744	553	0

Missing Hours

1099	801	752	743	744	721	744	0	0	0	167	744

7,333 Hours of Good Data 6,515 Hours Missing 53.0% Data Recovery

Wind-Hydro Phase I Study

Pumped Hydro Findings & Recommendations

Abstract

This purpose of this study is to identify sites that may be feasible for constructing a pumped-storage hydropower system on the Lower Brule Sioux Tribe Reservation as a part of the firm power delivery system. This analysis is one of several energy options reviewed for the tribe to support an electrical delivery system, a firm energy source, for a proposed wind farm and a community power delivery system.

Areas around Lower Brule Tribal lands have the limited geographical attributes to support a commercially viable pumped storage system given the two required critical items of net effective head and water flow. The dynamic head is limited to 200 feet for which severely limited the energy production from any hydro turbine. The minimum amount of water required is over 52 acre-ft to produce a 1,088 kW of electrical power for the given net effective head at 200 ft for a 6-hour period. To support a small 10 MW wind farm as a firming option over 20 holding reservoirs would have to be constructed around along the hills above Lake Sharpe.

Other concerns:

1. The physical requirement for storing the water and the required net effective head is limited for the rest of the Lower Brule Tribal Lands.
2. The energy production from low net effective head hydro turbine would not be enough to interconnect with the 69 kV transmission line near the project site.
3. Environmental and permitting concerns for an open pumped storage system would be very difficult to permit and time consuming.
4. The high capital cost in addressing a small community load demand.

Using a hydro pumped storage system to meet a demand requirement and as a firming option is very feasible in an area when electrical energy cost are extremely high. Base on summary billings, Lower Brule Tribe operational buildings are charges about $0.06/kWh which is a nationwide average. This energy cost would be difficult to match.

Pumped Storage Hydropower System Description

Pumped hydropower is an energy storage system that is used to store off-peak power generation from other power sources. That off-peak generation is then used to meet peak load needs or to provide emergency power injection to the grid when a plant goes offline. When the demand for electricity is low, pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir to generate electricity as shown in Figure 1.

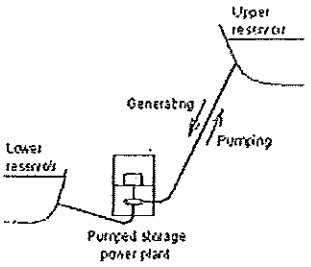


Figure 1 Pumped storage scheme configuration

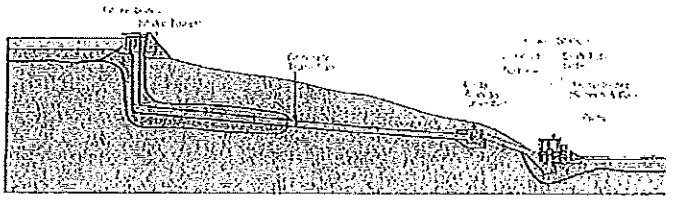


Figure 1b Pumped storage scheme configuration

Technical

Location and History

Several areas along the banks of the Missouri River on the Lower Brule Sioux Tribe side were reviewed. The ideal project area needs to have a high elevation and be capable of storing large amounts of the water. The physical limitation for the net effective head is the difference of the lowest elevation and the highest elevation within tribal boundaries. The lowest elevation is Lake Sharpe which is at the elevation of 1423 ft. The highest elevation around the project areas were 1760 ft. The most available net effect head is 337 ft for these project areas.

Hydropower

Maximum Net Effective Head Available

To utilize the available net effective head of 337 ft a tank or upper reservoir would have to be constructed on the top of the highest ridge and the hydro turbine located at the Lake Sharpe elevation. Its believed that using Lake Sharpe as the lower reservoir would not be allowed due to the regulatory and environmental constraints. The Army Corps of Engineer will require an extensive environmental review to allow raw water discharge

into Lake Sharpe. Discussion was initiated with the Army Corp of Engineers regarding the pumped storage system. The Corp recommended that a closed pumped storage system is more acceptable by the regulatory agencies such as FERC and EPA. A closed pumped storage systems means using 2 reservoirs, upper and lower, *without* having to discharge into Lake Sharpe, thereby eliminating possible of cross contamination. The lower reservoir would have to be constructed above the lake's elevation of 1,423 ft which reduces the net effective head.

The highest elevation point would be at ridges along the banks. The top of these ridges are at an elevation of 1760 ft. Unless large tanks were built at these high elevation points, the available net head would have to be reduced. Most of the project areas capable of holding large amounts of water are at the elevation of 1700 ft.

Therefore, a new lower reservoir will have to be constructed above Lake Sharpe at the approximate elevation level of 1500 ft and the highest elevation level would be at 1700 ft so the assumed net effective head of 200 ft will be used for this analysis.

A make up water system would have to be installed and draw water from the actual lake to makeup the loss of due the evaporation of the pumped storage reservoirs.

Hydro Turbine

A hydro turbine such as one provided from the Gilkes Company would suffice for this analysis. The hydro turbine performance rating is as follows: Rated power output of 544 kW, 200 ft net head, with flow at 35 cubic feet per second (cfs) or 262 gallons per minute (gpm). This turbine is only designed for a constant head and flow to generate the rated power output. As of this report, a pump/turbine equipment setup for this analysis could not be found but the logistical analysis will stay the same. The installed cost for the hydroturbine is typically $1400/kW (Gilkes rep).

Amount of Water Storage Required

Given the performance of the hydro turbine and required net effective head of 200 ft with a flow rate of 35 cfs or 262 gpm, the minimum amount of storage water needed for a given amount of time can now be determined. Table 1 show the minimum amount of water needed to flow through a single turbine at the required head to produce the electrical power.

*Water Storage needed = flow rate * 60 min/hr * demand period hr*

Demand Period (hours)	Water Storage Needed (gallons)	Water Storage Needed (acre-ft)	Water Storage Needed (cubic feet)
4	3,769,920	11.57	504,000
6	5,654,880	17.35	756,000
8	7,539,840	23.14	1,008,000
10	9,424,800	28.92	12,600,000

Table 1

Now that the minimum volume of water storage needed for one hydro turbine has been determined, the next item to select is to select the reservoir sites.
As previously mentioned, a tank could be installed at the highest elevation to serve as the upper reservoir source. By taking the minimum volume of water needed for the turbine to work, we can determine the minimum tank size. We will use volume calculated for the 6 hour period. The tank size for the minimum amount of water to operate the hydro turbine for a 6-hour period of time show in Table 2:

Demand Period Of 6 hours	*Tank Radius* At the following depth.		
Depth	20 ft	30 ft	40 ft
1 turbine	*110 ft*	*90 ft*	*78 ft*
3 turbines	*190 ft*	*155 ft*	*134 ft*
10 turbines	*347 ft*	*283 ft*	*245 ft*
19 turbines	*478 ft*	*390 ft*	*338 ft*

Table 2

For one turbine to operate the required tank size would be at least 90 ft in diameter and 30 ft tall.

The same principle would be applied to an open aired reservoir.

Demand Period Of 6 hours	*Reservoir Surface Area (acre)* **At the following depth.**		
Depth	**20 ft**	**30 ft**	**40 ft**
1 turbine (544kW)	*.87*	*.58*	*.43*
3 turbines (1632 kW	*2.60*	*1.74*	*1.30*
10 turbines (5440 kW)	*8.68*	*5.79*	*4.34*
19 turbines (10,336 kW	*16.49*	*10.99*	*8.24*

For one turbine to operate the rate output, the upper and lower reservoirs would each be at a minimum size at 0.58 surface acres at 30 ft depth.

Conclusion

This study was initiated to determine if a pumped storage system would be feasible as a "firming" option for a possible wind farm that would be developed by Lower Brule Sioux Tribe on Tribal lands. Unfortunately, the topography of the Tribe's land is limited to a net effective head of 200 ft which limits the electrical out of any hydro turbine.

	gross head (ft)	Flow (cfs)	(gpm)	0.55	0.085	Power (kw)	Gallons needed for 6 hour period	Acre-ft for 6 hour period
	200	35	261.8	0.91	0.085	541.45	5,654,880.00	17.35
3	200	105	785.4	0.91	0.085	1,624.35	16,964,640.00	52.06
10	200	350	2618	0.91	0.085	5,414.50	56,548,800.00	173.54
19	200	665	4974.2	0.91	0.085	10,287.55	107,442,720.00	329.73
	100.00	100	748	0.55	0.085	100.00	16,156,800.00	49.58
	200.00	35.00	262	0.91	0.085	544.00	5,654,880.00	17.35
	200.00	35.00	262	0.91	0.085	544.00	5,654,880.00	17.35
	200.00	35.00	262	0.91	0.085	544.00	5,654,880.00	17.35
						1,632.00	16,964,640.00	52.06
							20,357,568.00	62.48

			Sell	Demand $/kw	$/kwh (10 hrs)	
				$0.00	0.02	
300	356.51			$ -	$ 326.40	
		Daily profit	$ (15,331.98)		$ 326.40	buy

	200 ft		180 ft		
max velocity	113.5 ft/s			107 ft/s	
	Dia (in)	cfs	Dia (in)	cfs	
	6	22.27		12	84.00
	8	39.60		24	335.98
	12	89.10		36	755.96
	48	1425.56		48	1343.92
	72	3207.51		72	3023.82
	96	5702.24		96	5375.68
	118	8615.23		118	8121.85

61 meters	200.1288 ft				
1 m3/sec	35.3144 cfs	264.151712	5,705,676.98	17.51	
1000 kW					

head	velocity
200	113.5

energy to pump water (kw) assume 74%		Depth (ft) 20	30	40
			Area (sqft)	
731.69		37,800.00	25,200.00	18,900.00
2,195.07		113,400.00	75,600.00	56,700.00
7,316.89		378,000.00	252,000.00	189,000.00
13,902.09		718,200.00	478,800.00	359,100.00
135.14		108,000.00	72,000.00	54,000.00
735.14		37,800.00	25,200.00	18,900.00
735.14		37,800.00	25,200.00	18,900.00
735.14		37,800.00	25,200.00	18,900.00
2,205.41		113,400.00	75,600.00	56,700.00
Demand $/kw	$/kwh (10hr)	0.87	0.58	0.43
6.5	0.06	2.60	1.74	1.30
$ 14,335.14	$ 1,323.24	8.68	5.79	4.34
		16.49	10.99	8.24
	$ 15,658.38			

Width 20 ft	30 ft	300 ft 40 ft	depth
126.00	84.00	63.00	
378.00	252.00	189.00	
1,260.00	840.00	630.00	
2,394.00	1,596.00	1,197.00	
360.00	240.00	180.00	
126.00	84.00	63.00	
126.00	84.00	63.00	
126.00	84.00	63.00	
378.00	252.00	189.00	

Here are some of the conversion factors you may need to ass feasibility:
1 cubic foot (cf) = 7.48 gallons;
1 cubic foot per second (cfs) = 448.8 gallons per minute (gpm)
1 cf = 0.028 cubic meters (cm);
1 cubic meter per second (cm/s) = 15,842 gpm;
1 pound per square inch (psi) of pressure = 2.31 feet (head) o
kilowatt (kW) = 1.34 horsepower (hp);
1 hp = 746 Watts

Radius ft		
20 ft	30 ft	40 ft
109.72	89.59	77.58
190.04	155.17	134.38
346.96	283.29	245.34
478.25	390.49	338.18
	-	-
185.46	151.43	131.14
	-	-
109.72	89.59	77.58
109.72	89.59	77.58
109.72	89.59	77.58
190.04	155.17	134.38

_____

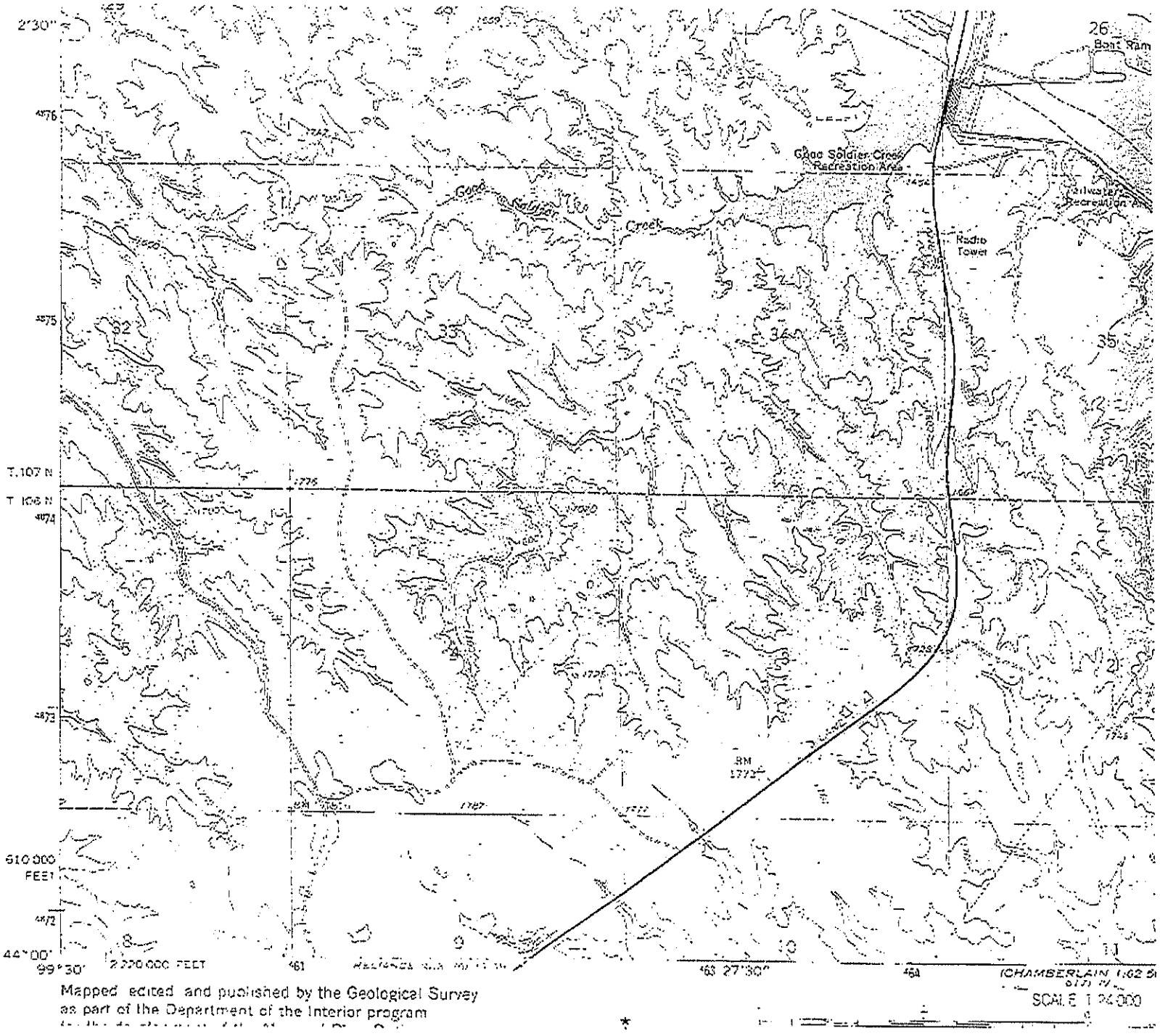
ı to assess your site's

e (gpm);

ıead) of water;

HP=h * Q/3956

		HP	kW	6 hour period kW-Hr	$0.06
h=	200				
Q1 (gal/min)	100	5.06	3.8	22.62	$1.36
Q2 (gal/min)	200	10.11	7.5	45.24	$2.71
Q3 (gal/min)	500	25.28	18.8	113.10	$6.79
Q4 (gal/min)	1000	50.56	37.7	226.20	$13.57
Q5 (gal/min)	3000	151.67	113.1	678.59	$40.72
Q5 (gal/min)	10000	505.56	377.0	2261.98	$135.72



Mapped edited and published by the Geological Survey
as part of the Department of the Interior program

Abstract

This purpose of this study is to determine the feasibility of constructing a hydropower system using the tail race of the Big Bend Dam on the Lower Brule Sioux Tribe Reservation as a part of the firm power delivery system. This analysis is one of several energy options reviewed for the tribe to support an electrical delivery system for a proposed 10 MW wind farm.

The construction of a tail race hydropower system is dependent on 2 critical items, the net effective head and water flow from discharge side of the Big Bend Dam. The mechanical and physical parameters in using hydropower equipment are not present. The net effective head is not available since the tail race of Big Bend Dam flows into another lake. The available head in the dam tailrace is approximately 3 ft. The flow rate is very high at 103,000 cubic feet per second. **Hydroturbines that currently use low head technologies only produce less 100 kW which are used in areas where no other forms of electrical power exist.**

The decision to proceed or not with this course of action will be at the sole discretion of the Lower Brule Sioux Tribe but the mechanical parameters is not present.

Tail Race Hydropower System Description

The Tail Race Hydropower system utilizes the water flow and head downstream from an existing structure such as a dam. In this case, the energy resource of the Big Bend Dam will be examined.

Technical

Location and History

The tail waters of the Big Bend Dam of Lake Sharpe on the Missouri River on the Lower Brule Sioux Tribe side were reviewed. The ideal project area is to have the tail waters continue to flow at a high rate of speed once it gets discharge from the dam. The Big Ben Dam tail waters discharges approximately at the same elevation of the lower lake so the flow decreases. The available head displacement is not present. The area below the tailwaters does not support a diversion canal to install another low head hydroturbine. The land topography in the tailwater area would not allow for a constant flow through any mechanism.

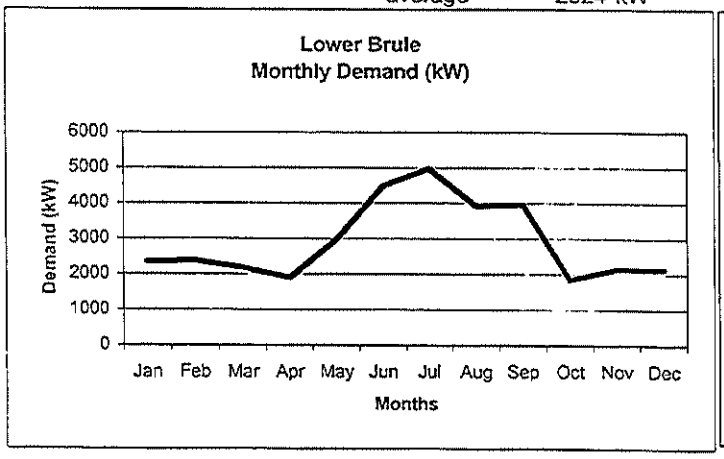
The Big Bend Dam is an earthen fill dam that holds an average 1,682,000 acre feet of water. The power facility at the dam contains 5 unit Kaplan type propeller hydroturbine

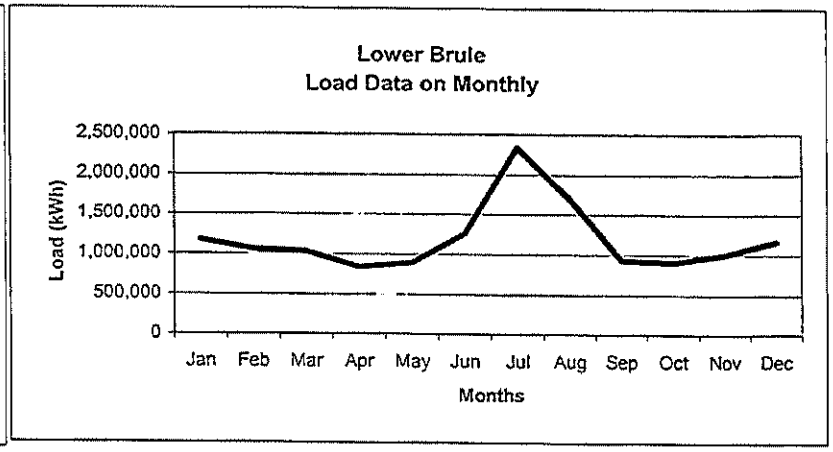
units. The usable average head is 67 feet. The total flow into these turbines at that average head is 103,000 cubic feet per second. The power facility can produce 493,320 kW or 493 MW.

The average elevation of Lake Sharpe is at 1420 ft. The average elevation of Lake Francis is 1354 ft. The difference is 66 ft.

	2002	2003	2004	Average
Jan	1961	2400	2630	2330
Feb	2177	2400	2506	2361
Mar	2098	2362	2033	2164
Apr	1956	1718	1980	1885
May	3991	2508	2374	2958
Jun	4826	4015	4589	4477
Jul	5057	4882	4961	4967
Aug	4411	3427		3919
Sep	3943	3965		3954
Oct	1874	1795		1835
Nov	1870	2383		2127
Dec	1985	2237		2111
				35086 kW
		per kW	$ 9.00	$315,777.00
		average		2924 kW

	2002	2003	2004	Average
	943,200	1,243,200	1,324,800	1,170,400
	933,600	1,075,200	1,140,000	1,049,600
	1,123,200	979,200	979,200	1,027,200
	768,000	832,800	890,400	830,400
	916,800	883,200	861,600	887,200
	1,533,600	1,104,000	1,128,000	1,255,200
	2,553,600	2,385,600	2,076,000	2,338,400
	1,495,200	1,891,200		1,693,200
	868,800	986,400		927,600
	859,200	938,400		898,800
	988,800	998,400		993,600
	1,101,600	1,219,200		1,160,400
				14,232,000 kWh
			per kWh	$ 0.06 $ 853,920.00

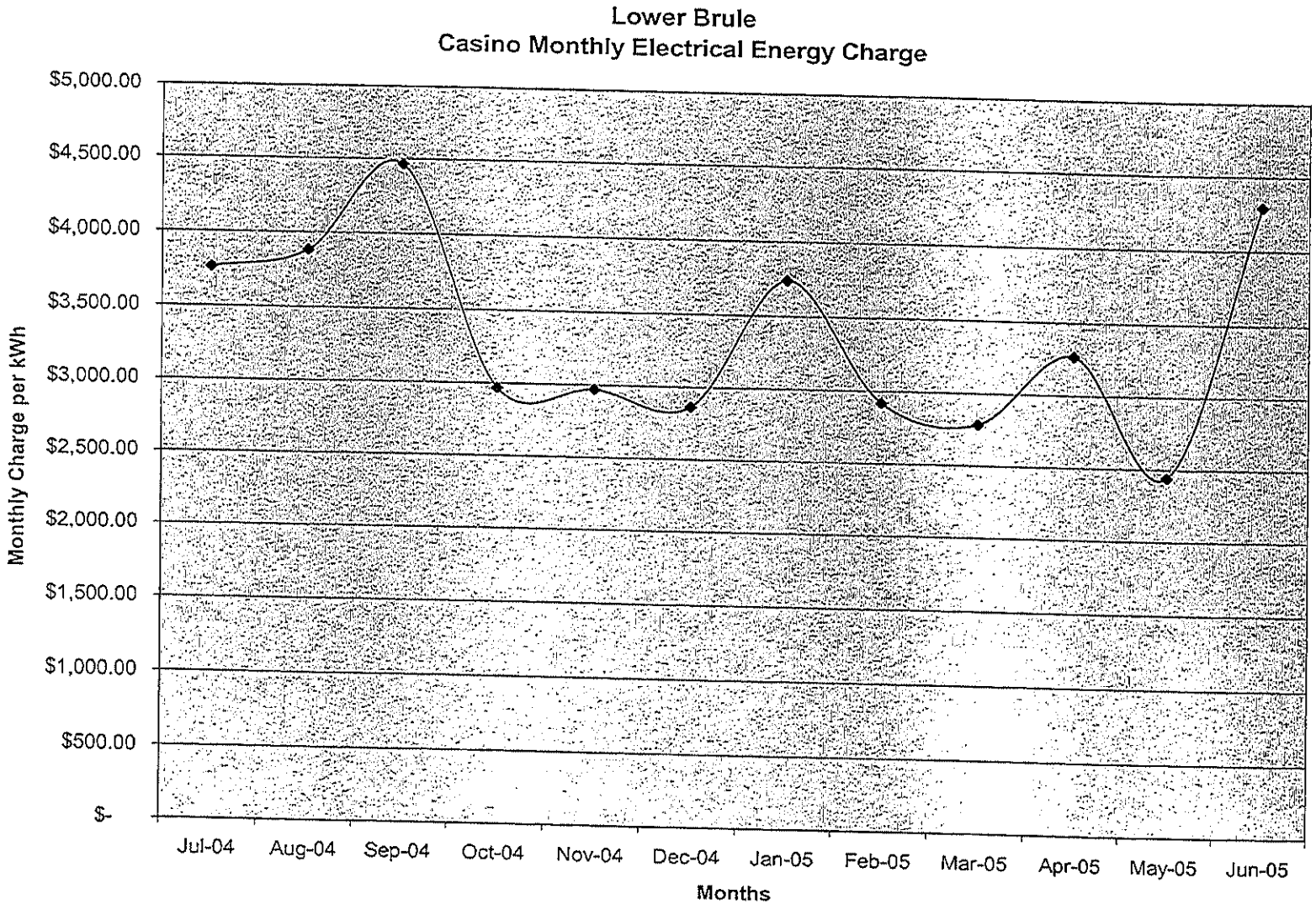


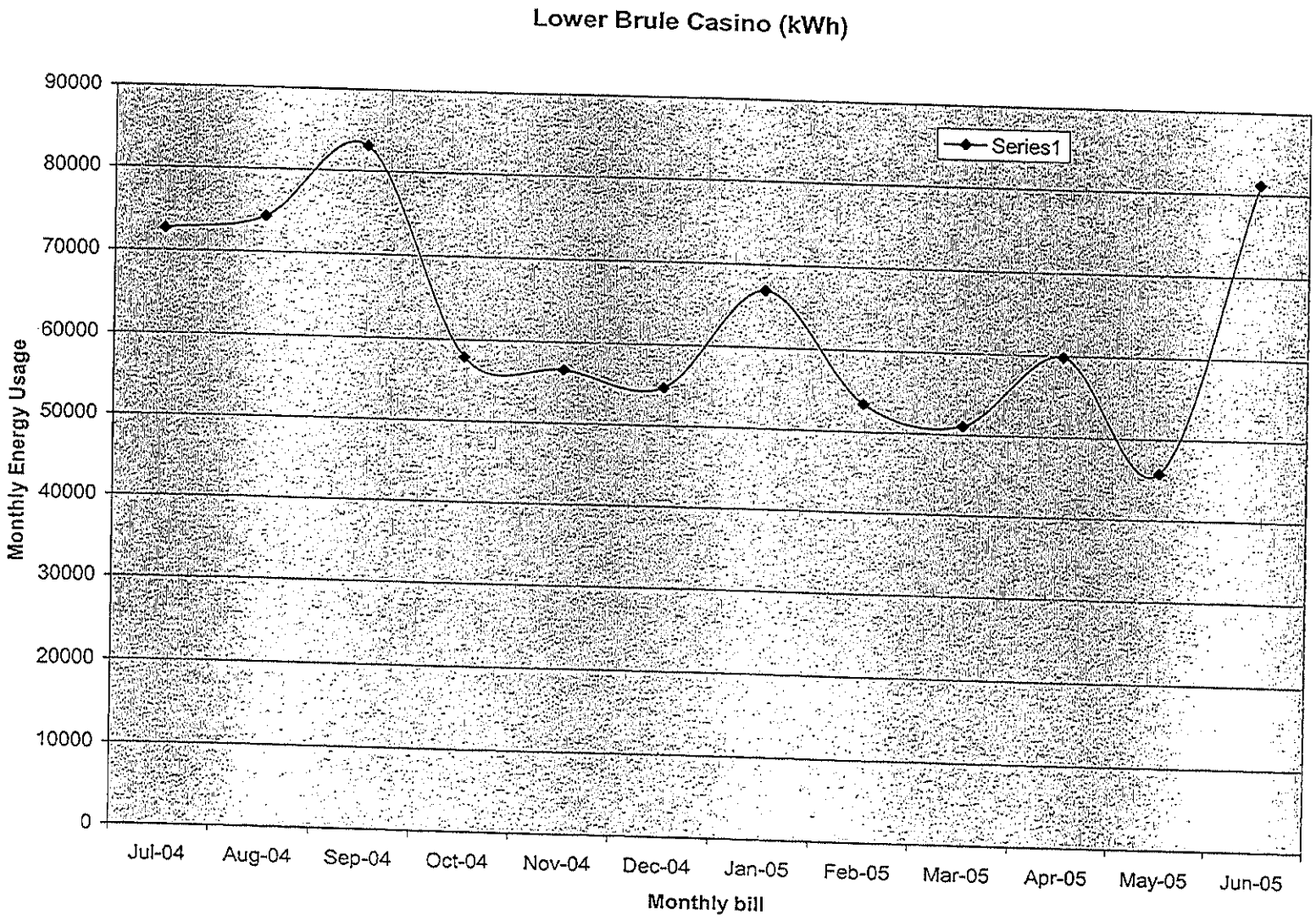


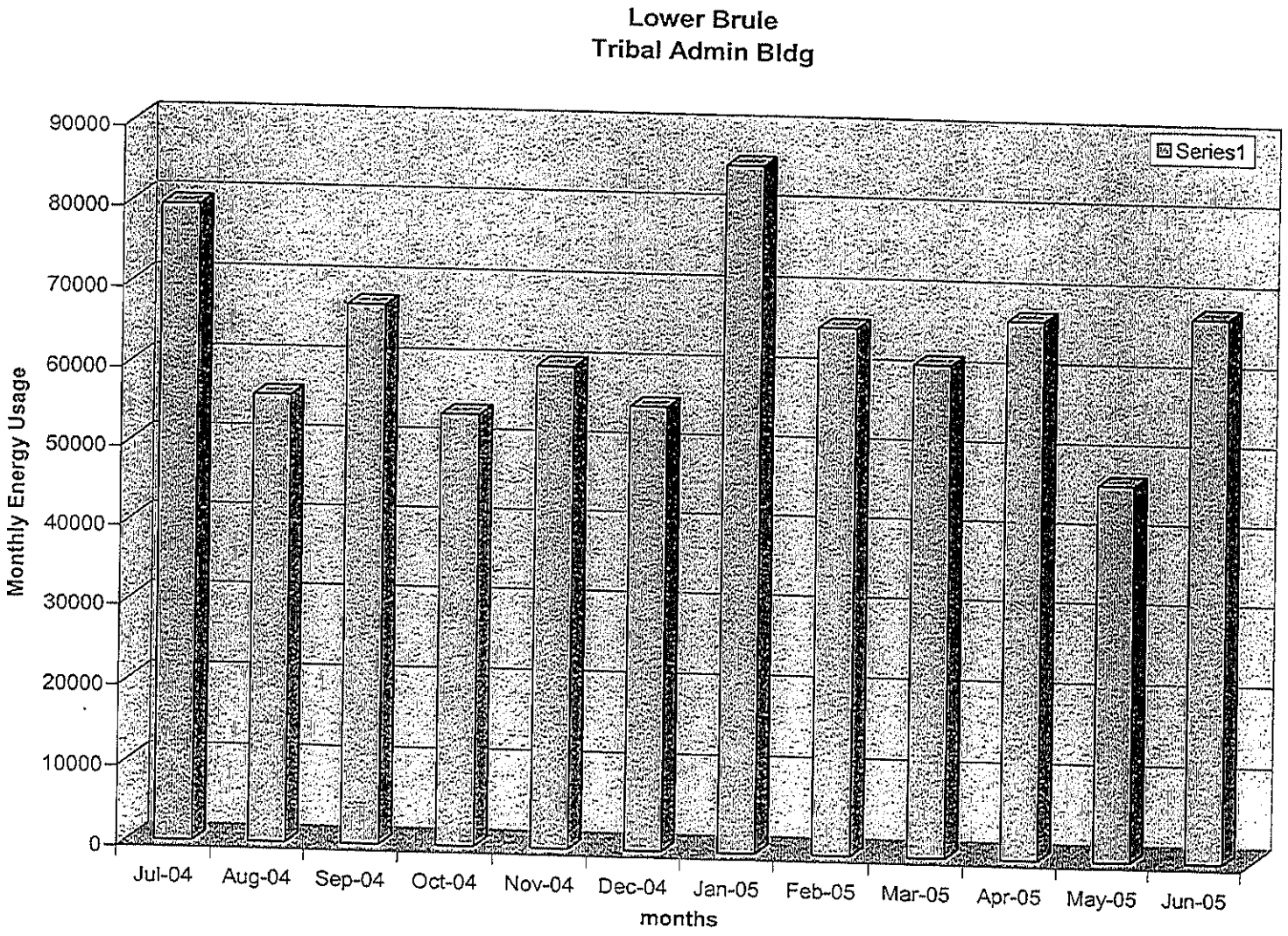
Sub	Phase	ABC	FT. THOMSPSON DELIVERY					
21	Lower Brule			Meter No.	14242	2400	Mult.	Reading
2002	Hours	KW Rdg	DEM	KWH Rdg	KWH	LF	23625	
Jan	696	0.82	1961	24018	943,200	69%		
Feb	672	0.91	2177	24407	933,600	64%		
Mar	768	0.87	2098	24875	1,123,200	70%		
Apr	720	0.82	1956	25105	766,000	55%		
May	792	1.66	3991	25577	916,800	23%		
Jun	672	2.01	4826	26216	1,533,600	47%		
Jul	744	2.11	5057	27280	2,553,600	58%		
Aug	792	1.84	4411	27803	1,495,200	43%		
Sep	672	1.64	3943	28265	868,800	33%		
Oct	744	0.78	1874	28623	859,200	62%		
Nov	744	0.78	1870	29035	988,800	71%		
Dec	744	0.83	1985	29494	1,101,600	75%		
8760	8760	Total KW	36149	Total KWH	14,085,600			

Sub	Phase	ABC	FT. THOMSPSON DELIVERY					
21	Lower Brule			Meter No.	14242	2400	Mult.	Reading
2003	Hours	KW Rdg	DEM	KWH Rdg	KWH	LF	29494	
Jan	768	1	2400	30012	1,243,200	67%		
Feb	672	1	2400	30460	1,075,200	67%		
Mar	744	0.98	2362	30868	979,200	56%		
Apr	720	0.72	1718	31215	832,800	67%		
May	768	1.05	2508	31583	883,200	46%		
Jun	696	1.67	4015	32043	1,104,000	40%		
Jul	744	2.03	4882	33037	2,385,600	66%		
Aug	744	1.43	3427	33825	1,891,200	74%		
Sep	696	1.65	3965	34236	986,400	36%		
Oct	792	0.75	1795	34627	938,400	66%		
Nov	672	0.99	2383	35043	998,400	62%		
Dec	768	0.93	2237	35551	1,219,200	71%		
8760	8784	Total KW	34092	Total KWH	14,536,800			

Sub	Phase	ABC	FT. THOMSPSON DELIVERY					
21	Lower Brule			Meter No.	14242	2400	Mult.	Reading
2004	Hours	KW Rdg	DEM	KWH Rdg	KWH	LF	35551	
Jan	744	1.1	2630	36103	1,324,800	68%		
Feb	696	1.04	2506	36578	1,140,000	65%		
Mar	720	0.85	2033	36586	979,200	67%		
Apr	768	0.83	1980	37357	899,400	59%		
May	696	0.99	2374	37716	861,600	52%		
Jun	720	1.91	4559	38196	1,126,000	34%		
Jul	768	2.07	4961	39051	2,076,000	54%		
Aug			0		-	#DIV/0!		
Sep			0		-	#DIV/0!		
Oct			0		-	#DIV/0!		
Nov			0		-	#DIV/0!		
Dec			0		-	#DIV/0!		
8760	5112	Total KW	21072	Total KWH	9,406,000			


Lower Brule
Casino Monthly Electrical Energy Charge
$5,000.00
$4,500.00
$4,000.00
$3,500.00
$3,000.00
$2,500.00
$2,000.00
$1,500.00
$1,000.00
$500.00
$-
Monthly Charge per kWh
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Months


Lower Brule Casino (kWh)
Series1
Monthly Energy Usage
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Monthly bill


Lower Brule
Tribal Admin Bldg
Monthly Energy Usage
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Series1
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
months